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A New Frog (*Syrrhophus*) From the Sinaloan Lowlands of Mexico

By David A. Langebartel and Frederick A. Shannon

A series of 10 specimens of a new species of *Syrrhophus* was collected in the low hills of the Sinaloa lowlands, 36 miles north of Mazatlán on November 17, 1955, by Ernest C. Bay, Joseph C. Schaffner, and David A. Langebartel. The collecting site was a rocky creek bed near the highway. This is well within the region of the Tropical Deciduous Forest. A return stop at the same locality on January 17, 1956, netted three more specimens of the same frog. All were taken from the creek bottom in moist stretches but not in inundated areas. The frogs seemed to show a preference for the creek edge, where the accumulation of leaves offered a good source of cover. At both times several specimens of frogs were calling from trees along the creek. The call was a simple "peep", similar to that of *Syrrhophus*, but the collectors were unable to find the calling individuals, and therefore it is not certain whether they belonged to the same poulation as the frogs that were collected.

The symbols UIMNH and FAS refer to specimen numbers in the collections of the University of Illinois Museum of Natural History and F. A. Shannon, respectively.

Syrrhophus interorbitalis sp. nov.

Holotype. FAS No. 9378, collected from a rocky stream bed 36 miles north of Mazatlán (center of city), Sinaloa, on Nov. 17, 1955, by Bay, Schaffner, and Langebartel.

*Paratypes.** FAS Nos. 9379-9382 and UIMNH Nos. 38095-9 from the same locality and same date, and UIMNH No. 38094 from the same locality, collected January 17, 1956.

Diagnosis. A species of the genus *Syrrhophus* with two palmar tubercles, placing it in the Sierra Occidental complex of Firschein (1954,

* The authors realize that paratypes no longer have official sanction but are retaining the term in the belief that it subserves a useful function.

Fig. 1. Dorsal view of *Syrrhophus interorbitalis* sp. nov., holotype, FAS No. 9378, about X 2½.

Copeia, 1:48-58). It has the two outer fingers markedly widened at the tip; a smooth, unmarked venter; a relatively smooth dorsum; a distinct variegated dorsal pattern extending little down the sides of the body. There is a broad whitish interorbital band, not evident to such a strong degree, if at all, in any other known *Syrrhophus*. The species extends more to the northwest than any other known to the genus. It is undoubtedly most closely related to *S. pipilans* in the dilated toe tip and in the nature of pigment distribution, but differs from *pipilans* to a minor degree in that the toe tips are proportionally more dilated and the tympanum relatively smaller; to a major degree it differs from *pipilans* in that it has a contrasting dorsal pattern, a strongly delineated whitish band between the eyes, and a whitish venter. *S. modestus* is much smaller than *interorbitalis*, and the pattern is quite different.

Description of holotype. Head as wide as or wider than body; eyes protuberant, extending beyond sides of head; eye width slightly greater than interorbital width and nearly three times diameter of tympanum; tympanum vertical, indistinct but not covered by loose skin. Canthus rounded; sides of snout nearly vertical; nostrils small, lateral, well back from tip of snout; internarial distance less than that of eye-nostril.

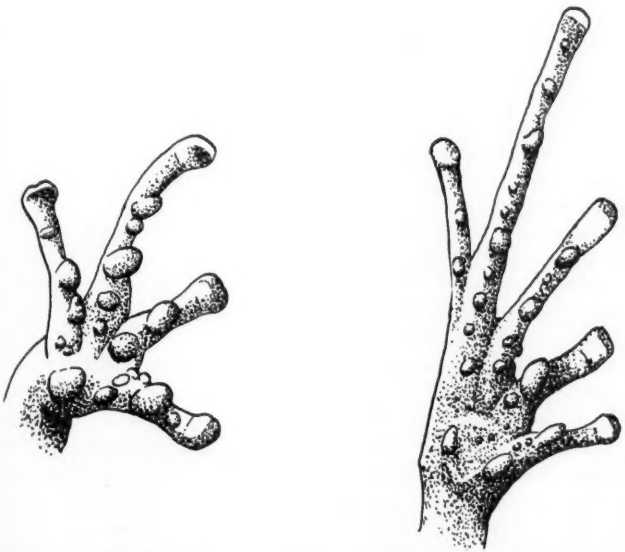

Fig. 2. Volar surfaces of right hand (left) and right foot (right) of holotype of *Syrrhophus interorbitalis* sp. nov.

Tongue rounded, free laterally and posteriorly; not or but faintly notched posteriorly; vomerine teeth absent; choanae small.

Skin on top of head and dorsum of body smooth, with scattered minute, flat pustules; no lumbar gland. Brachium and antebrachium elongate, slender, smooth; hand without trace of web; digital formula, 2-1-3-4; 3rd and 4th finger tips truncate, dilated, 2½ times as wide as finger; two palmar tubercles, lateral larger than median; supernumerary tubercles present on palm; subarticular tubercles distinct, single. Leg relatively short, extended tibiotarsal joint barely reaching eye; adpressed heels not meeting medially; tarsal fold absent; median metatarsal tubercle large, distinct; lateral metatarsal tubercle smaller, distinct; small supernumerary tubercles on sole of foot. Toes not webbed; digital formula 4-3-5-2-1; 1st to 4th toe tips slightly dilated, truncate; subarticular tubercles single, distinct. Anus small, located dorsally, just above femoral level.

Ventral surfaces smooth except for pebbly corrugations on posteroventral surfaces of femora; similar corrugations on ventrolateral body surfaces. Ventral disc terminating well short of femoral junction.

Measurements of holotype in millimeters. Snout-vent, 28.3; head length, 9.0; head width, 9.0; eye, 3.4; eye-nostril, 3.3; internarial width, 2.8; interorbital width, 3.1; diameter of tympanum, 1.3; nostril to end of snout, 1.7; femur, 11.8; tibia, 11.4; hind foot, 11.0; diameter of 3rd toe disc, 1.3; diameter of 3rd toe, 0.55; width of interorbital band, 3.0.

Color pattern of holotype. Dorsal color of head and back mottled dark on a contrasting, light purplish ground color. A distinct interorbital band of the light ground color bordered with dark extends laterally to the edge of the eyes. Marbling on the arms and legs tends to take the form of cross banding, especially on the tibial surfaces; ventral and ventro-lateral surfaces of animal are uniformly off-white.

Variation in the paratype series is slight. Occasional specimens tend to have a slight increase in the proportion of dark dorsal pigmentation to lighter background. In such cases there is even more emphasis of the striking interorbital light band. All individuals have rounded tongues.

Remarks. A brief review of *Syrrhophus* and *Tomodactylus* makes it evident that the two genera are closely related. Firschein (*op. cit.*) comments upon the not-too-great distinction of *Syrrhophus,* but dwells more upon its relationship with *Eleutherodactylus* rather than with *Tomodactylus,* although he infers that the latter genus is closely allied with *Syrrhophus.* Of the genera *Eleutherodactylus, Microbatrachylus, Syrrhophus,* and *Tomodactylus,* he opines that the last named "is the most uncertain in position," believing that the presence of a lumbar gland is not enough of a character to define the genus. Firschein lists a combination of characters that he feels would define *Syrrhophus,* but a study of appropriate specimens indicates that all these characters are present in at least some

Tomodactylus species. Therefore, we feel that it is proper and reasonable to use the presence of the lumbar gland as a key character for *Tomodactylus*.

We have placed *interorbitalis* in the genus *Syrrhophus* for the following reasons: lack of a lumbar gland; marked dilation of the tips of the two outer fingers, a condition not present in known *Tomodactylus* but evident in certain previously described *Syrrhophus* (*pipilans, modestus, latodactylus,* and *nebulosus*); as presently known, no lowland form of *Tomodactylus* exists, but there are several lowland *Syrrhophus, e.g., modestus,* of Colima, and *pipilans,* of Guerrero and Oaxaca. *Tomodactylus* appears to be confined to the highlands of the central plateau and its periphery. Perhaps the sadly neglected subgeneric category should be utilized here to represent the relationship between the two species groups. Mr. James Dixon of Texas A. and M. College is at present monographing *Tomodactylus,* and his study may help to clarify the relationships.

The phylogenetic relationships of *pipilans* and *interorbitalis* are suggested not only by their basic pigmentation and structure, but may be inferred also from their ranges. Both are species of Pacific slopes, separated presumably by a geographic hiatus and occupying somewhat similar habitats. However, *pipilans* does not have the contrasting pattern of *interorbitalis;* the former species is dull brown dorsally with indistinct darker mottling. Likewise, *pipilans* lacks an interorbital light band, the only evidence in occasional specimens being a slightly darker pigmented area on the outer edges of where the band should be. The lesser dilation of finger tips and the larger area of the tympanum in *pipilans* may be indicated from UIMNH No. 9502 from 7 mi. S El Candelaria, Oaxaca. The specimen measures 28.5 mm., which is slightly larger than the 28.3 mm. of the holotype of *interorbitalis*. The diameter of the 3rd finger tip is 0.95 for *pipilans,* 1.3 for *interorbitalis*. The tympanal diameter is 2.1 mm. for *pipilans,* 1.3 for *interorbitalis*. The diameter of the eye is 3.7 in *pipilans,* 3.4 in *interorbitalis*. It does not seem likely that these two populations are subspecies.

We thank Ellen C. Shannon for the illustrations and for certain criticisms.

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AQUATIC HIBERNATION OF THE RED-BACKED SALAMANDER.—There are many reports of terrestrial hibernation of the red-backed salamander in the literature, including Mansueti (1945, Md., 15: 59) and Grizzell (1949, Copeia: 231-2) for Maryland. Apparently, however, the occurrence of *Plethodon c. cinereus* (Green) in aquatic situations is unknown. Bishop, in his report on New York salamanders (1941, N. Y. State Mus. Bull., 324: 210) says, "The red-backed sala-

mander is entirely terrestrial and usually nocturnal in its habits." Again (*op. cit.*: 211), "The red-backed salamander can swim but its movements are labored and every attempt is made to escape from the water into which it apparently never enters voluntarily." The same writer cites (*op. cit.*: 211-12) from Cochran (1911, Biol. Bull., 20: 339) the inclusion of rat-tail maggots and mosquito wigglers in the diet of *cinereus*. He concludes that this suggests ". . . feeding in some cases in the immediate vicinity of water or at least in very damp situations." Littleford *et al.* (1947, Ecology, 28: 445) report finding *cinereus* ". . . in situations ranging all the way from wet to those that might be considered dry." The term "wet" is not explained, but presumably it means a very moist situation, not aquatic.

On January 5, 1947, a small, dormant specimen of this salamander was found under a stone in ten inches of water in a spring-pool near Finksburg, Carroll County. Nearby, under a stone in the less shallow stream, two adult specimens were found, along with *Desmognathus fuscus fuscus* (Green) and *Rana palustris* LeConte. They were partially torpid but attempted to escape when uncovered. This stream, unlike the deep pool source, was choked and covered with leaves. The area is in Maryland's Piedmont Plateau.

An adult lead-backed *cinereus* was caught as it emerged from submerged moss in a small pool (app. 3" deep) in the Cedarville State Forest on the night of March 23, 1951 (Cooper, Md. Naturalist, 1953, 23: 95) with a water temperature of 13° C. It is possible that this observation actually represents a terrestrial hibernation of the species, since the body of water was probably transient and the salamander may have been "under" before the advent of sufficient rains to fill the pools in the area. However, the salamander exhibited no frantic behavior, crawling slowly through the submerged moss and along its surface until captured.

These observations represent the only cases of aquatic habitat preference ever seen by this writer for the species concerned. It is one of the more abundant of Maryland salamanders and has been found in considerable quantity during spring and summer months, but always terrestrially. Perhaps *cinereus* has a definite home range, as suggested by Test and Bingham (1948, Amer. Midl. Nat., 39: 365-7). If so, it would probably choose the constant moisture of aquatic hibernation sites when available within its limits. Springs, with their relatively stable temperatures, would seem to be especially desirable. A constant low temperature, as opposed to the fluctuating soil temperatures found by Vernberg (1953, Ecology, 34: 55-62) in his study of an experimental hibernaculum containing *cinereus* and *Eurycea bislineata bislineata* (Green), would allow constant low metabolism and consequent retention of weight. Temperature fluctuations induce movements in the hibernating salamanders, up with increasing temperatures, down with decreasing, requiring the usage of energy reserves. Vernberg (*ibid.*) found a 57% mortality rate in terrestrially hibernating *cinereus*. It must be remembered, however, that this was an experimental study of a limited, enclosed area. *John E. Cooper, Department of Herpetology, Natural History Society of Maryland, Baltimore.*

Distributional Notes on Some Reptiles and Amphibians from Southern and Central Coahuila

By Charles M. Fugler and Robert G. Webb

This paper reports on a small collection of amphibians and reptiles obtained in southern and central Coahuila in the summer of 1955 by a field party of the University of Kansas Museum of Natural History and in the spring of 1954 by Mr. R. W. Dickerman.

Most of the specimens were taken at two localities. The first is in the arid southwest region at the town of Parras, elevation 5,470 feet, in the Chihuahua-Zacatecas Biotic Province (Central Tableland Biotic District) of Goldman (1951, Misc. Publ. Smithsonian Inst., 115) at the base of Sierra de Parras; the latter is one of the east-west trending ranges in southern Coahuila. This station is an irrigated valley; its dominant vegetation is huisache, mesquite and cholla. The second locality is near the crest of the Sierra Madre Oriental at an elevation of 9,950 feet in Cañon de Carolina, 13 miles east of San Antonio de las Alazanas. This locality is approximately one kilometer from the border of the state of Nuevo Léon, and specimens were taken in both states. This region is in the Sierra Madre Oriental Biotic Province of Goldman (*op. cit.*). Specimens from localities other than the two mentioned above were collected by Mr. Dickerman.

Especially noteworthy items in the collection are discussed in some detail hereinafter. Other species, all secured at Parras unless otherwise noted, are as follows: *Scaphiopus couchi rectifrenis* Cope, *Scaphiopus h. hammondi* Baird, *Bufo punctatus* Baird and Girard, *Bufo debilis insidior* Girard, *Cnemidophorus sacki semifasciatus* Cope, *Phrynosoma cornutum* (Harlan) (9 miles W La Rosa), *Uta stansburiana stejnegeri* Schmidt, *Sceloporus undulatus consobrinus* Baird and Girard, *Sceloporus grammicus disparilis* Stejneger (13 miles S San Antonio de las Alazanas), *Holbrookia maculata approximans* Baird, and *Crotalus atrox* Baird and Girard (3 miles E Americanos).

We are grateful to Dr. Edward H. Taylor and Mr. W. Leslie Burger for the identification and verification of certain specimens, and Dr. Hobart M. Smith for critical perusal of the manuscript and for certain suggestions.

Cnemidophorus inornatus Baird. Fourteen specimens (7 males and 7 females), KU 39472-85, were collected on July 4 at Parras.

The postantebranchials are slightly enlarged; they are never more than four times the size of the adjacent scales as in the various species of *sacki*. There are seven or eight light, longitudinal unbroken stripes, three on each side of a middorsal area that may consist of a single stripe (8 specimens), or two less distinct stripes (6 specimens). This variation may result from a geographic gradient; Burger (1950, Nat. Hist. Misc. 65:3) stated that specimens in the extreme northwestern part of the range of *C. inornatus* have no light stripes in the middorsal areas, whereas specimens from the extreme southeast have one or two light stripes. The dark interspaces between the lateral light stripes are wider (12 scales) than

the interspaces between the paravertebral stripes and the middorsal stripes. The paravertebral stripes are separated by 8-13 scales at midbody. Femoral pores range from 16 to 21. Both sexes have a light blue venter, somewhat more intense in males. The females range in snout-vent length from 51 mm to 57 mm, and all are sexually mature; the largest number of oviducal eggs was two. The largest egg measured 16 mm by 8 mm. The males range in snout-vent length from 49 mm to 60 mm and are presumably sexually mature.

Schmidt and Owens (1944, Zool. Ser. Field Mus. Nat. Hist., 29:106), under the name of *Cnemidophorus inornatus*, list specimens from Quatro Cienagas. Their specimens seem not to be *C. inornatus*, as currently defined by Burger (*op. cit.*:3), but seem to be referable to *C. sacki semifasciatus*. *Cnemidophorus octolineatus* recorded from Sierra de los Burros by the same authors (*op. cit.* :107) has been synonymized under the name *C. inornatus* by Burger (*loc. cit.*). The description by Schmidt and Owens (*loc. cit.*) indicates that there is a geographic gradient in the number of longitudinal light stripes, as was mentioned above.

Barisia imbricata ciliaris (Smith). Four adults and one juvenile, KU 39447-51, were collected 13 miles east of San Antonio de las Alazanas.

A female, KU 39451, taken on July 6, contains nine embryos, measuring 28 mm (1), 31 mm (3), 32 mm (1), 35 mm (2), and 37 mm (2) in length snout to vent. Details of scutellation are easily distinguishable in all embryos. The color of the embryos can be described as follows: anterior half of head gray; anterior half of pre- and suboculars black; interocular area gray; temporal area light gray, becoming black posteriorly; dorsum brown, occasionally spotted black; tail light brown, speckled black; two dorsolateral dark lines.

The diagnostic characters of the subspecies as defined by Tihen (1949, Univ. Kansas Sci. Bull., 33:244) are relatively constant in these specimens. The transverse dorsal scale rows average 40 (38-42). Longitudinal scale rows number 16 in all specimens. The nomenclature of the scale rows follows that of Tihen (*op. cit.* :219-220). The largest male measures 120 mm and the largest female measures 133 mm.

Each specimen is of uniform brown coloration dorsally; specimens vary from light brown to dark brown. In one specimen the head is reddish brown. The venter is white in all specimens. The single juvenile is uniformly dark dorsally. Except for the gravid female and the juvenile, the other specimens are spotted dorsally.

To our knowledge this is the second record of occurrence of this subspecies in the state of Coahuila. Smith (1942, Proc. U. S. Nat. Mus., 92:365) described the subspecies from specimens taken from Sierra de Guadelupe near General Cepeda in southern Coahuila. Presumably the high, east to west mountain ranges of southern Coahuila mark the northern periphery of the range of this subspecies. These specimens were collected at an elevation of 9,950 feet under logs; one was found about a foot above ground in a scrub oak. Taylor (1953, Univ. Kansas Sci. Bull., 35:1603) has reported the subspecies from an elevation of approximately 9,000 feet in San Luis Potosí. There is only one locality at low elevation (Smith and Taylor, 1950, Bull. U. S. Nat. Mus., 187:202) from which the subspecies has been recorded.

Eumeces dicei Ruthven and Gaige. To our knowledge there is reference in the literature to only 14 specimens of this species from four localities in Nuevo León and Tamaulipas (1, Ruthven and Gaige, 1933, Occ. Pap. Mus. Zool. Univ. Michigan, 206:1-3; 4, Dunn, 1936, Proc. Acad. Nat. Sci. Philadelphia, 88:471-474; 8, Taylor, 1943, Univ. Kansas Sci. Bull., 29:269-300; 1, Martín del Campo, 1953, Universidad, 11:111-152).

Twenty-two specimens (12 females and 10 males), KU 39533-54, were collected 13 miles east of San Antonio de las Alazanas. The specimens were collected on the ground under logs or wood cuttings; a few were found under the bark of cut upright stumps.

There is no significant difference in coloration between males and females. Small individuals (6, 38-41 mm) have a uniform brown dorsum, with evidence of a faint pale middorsal stripe; the dorsolateral stripes are distinct anteriorly, becoming less distinct immediately posterior to the insertion of the forelimbs. In adults, there is less marked anteroposterior distinction in the dorsolateral light stripes, and the latter may be bordered medially by small dark spots on each scale. These spots tend to form longitudinal lines (KU 39543, 39547), and other small spots are scattered irregularly over the dorsal surface (KU 39543). The brown dorsal surface, including the dorsolateral light stripes, involves six scale rows at midbody.

In preserved specimens the throat is pale and the venter bluish. In life, the side of the head and throat of the males was reddish; one, 41 mm in snout-vent length, was red on the side of the head but not on the throat. Two specimens (KU 39533, 39534) have the ventral surface of the tail reddish. Juveniles have blue tails.

All twenty-two specimens have 22 scale rows at midbody. Dorsal scales, counted along the middorsal line (excluding the nuchals), to a point even with the posterior border of the thigh when held at a right angle to the body, average 58 (53-60). Supralabials are usually 7-7; in two specimens they are 6-6; in two others they are 6-7. Infralabials are usually 7-7; in three specimens they are 6-7. The seventh supralabial is the largest and is usually separated from the ear opening by two small postlabials, whereas in KU 39545 and 39553 the supralabial is separated from the ear opening by two large postlabials. Nine individuals have the prefrontals separated. There are two pairs of nuchals; in two examples one of the posterior pair is divided. The presence of one large temporal, one postmental, the absence of a postnasal and the separation of the parietals by the interparietal appear to be constant characters.

Holbrookia texana scitula Peters. Seven specimens, KU 39453-59, were obtained on July 4 at Parras. Three of the seven are gravid females. Eggs removed from the uteri range in size from 5 x 8 mm to 14 x 8 mm. The eggs vary in number from two to four. The females range from 50 mm to 59 mm in snout to vent length; males range from 59 mm to 63 mm in snout to vent length. Ventral scales, counted from the collar to the anus, average 80 (75-84). The scales in the head length are 39 (35-40). Femoral pores average 28 (23-33). In all details of scutellation except for the number of ventral scales and femoral pores, the

specimens agree with the description of the subspecies as given by Peters (1951, Occ. Papers Mus. Zool. Univ. Michigan, 537:8-9).

The paired vertebral stripes mentioned by Peters (*loc. cit.*) are more prominent in females than in males, and are discernible only in smaller specimens. In large specimens the spots are not discernible.

Masticophis flagellum flavigularis (Hallowell). Two males, KU 39562, 39566, were obtained 21.5 miles east of Paila (by road) on July 5, and San Marcos (20 miles south of Quatro Cienagas). The scale characters are as follows: scale rows, 17-17-13, 17-17-12; ventrals, 193, 194; caudals, 106, 108; supralabials, 8-8; infralabials, 9-9, 8-9; preoculars, 2-2; loreals, 1-1.

In KU 39562 the head is dark brown; there is a light band across the nape of the neck. The chin is dark brown, mottled with white. There are dark bands on the anterior third of the body. On the neck there is a lateral stripe bordered by cream dorsally and ventrally. The color pattern is intermediate between that of juveniles and adults. The second specimen has no color pattern evident.

Masticophus taeniatus schotti Baird and Girard. A male, KU 39567, was taken 3 miles east of Americanos. The snake was discovered in the thatched roof of an abandoned hut. Scutellation data are as follows: scale rows, 15-15-12; ventrals, 205; caudals, 142; supralabials, 8-8; infralabials, 9-9; preoculars, 1-1; postoculars, 2-2; loreals, 1-1.

The dorsum is dark brown. The supralabials are mostly white; each is edged in brown except anteriorly. The venter is mottled brown; anteriorly the ventrals are edged by white irregular stripes. The caudals are white. Longitudinal lines are only slightly discernible. The head shields are unicolor. The edges of the postoculars, preoculars and loreals are white.

We have compared this specimen with a *schotti* from Medina County, Texas, KU 11688. The coloration is similar in both, except for the presence of neck bands and a distinct nape band in the Texas specimen. The venter is heavily mottled in both specimens. A specimen from Músquiz, KU 38331, is typical of *schotti.*

Pituophis catenifer affinis Hallowell. A single DOR, KU 39561, was recovered 4 miles east of Paila (by road) on July 5. Only the head and a small portion of the body were preservable. Scale data are as follows: four prefrontals; an azygous scale between frontals and prefrontals; rostral, although damaged, not twice as long as broad; preoculars 2-2; postoculars, 3-3; supralabials, 8-8; infralabials, 13-12; eye contacted by a single supralabial; sutures between supralabials and infralabials marked by dark streaks; loreals 1-1; 27 anterior scale rows. On the grounds of the known geographic distribution (Smith and Taylor, *op. cit.*: 106) and on the diagnostic characters of the subspecies, this snake is assigned to the subspecies *affinis.*

A male, KU 39565, was taken by R. W. Dickerman at Sierra Mojada. Scutellation data are as follows: scale rows, 29-32-31; ventrals, 220; caudals, 59; supralabials, 8-8; infralabials, 12-12; dorsal spots, 38; tail bars, 11.

Pituophis deppei deppei (Duméril). One specimen, KU 39564, was taken by R. W. Dickerman 16 miles east and 18 miles north of Ocampo.

Scutellation data are as follows: scale rows, 29-26-19; ventrals, 244; caudals, 90; supralabials, 9-7; prefrontals, 2.

The dorsum is uniformly brown; no spots are present on the body or tail. The subspecies *deppei* and *jani* are separable on the bases of the number of dorsal spots and the length of the interspaces between the dorsal spots (Stull, 1940, Bull. U. S. Nat. Mus., 175:43). This specimen is allocated to *deppei* on geographical grounds.

Storeria occipitomaculata hidalgoensis Taylor. Two females, KU 39445-46, were collected 13 miles east of San Antonio de las Alazanas. They were discovered under the bark of fallen logs. Data on scutellation are as follows: scale rows, 15-15-15; ventrals, 136; caudals, 43, 48; supralabials, 7-7, 6-6; infralabials, 7-7; body length, 156 mm., 206 mm.; tail length, 40 mm., 61 mm. The lower two rows of scales are not keeled. The characters exhibited by these specimens agree with those described by Trapido (1944, Amer. Midl. Nat., 31:14) for the subspecies.

In both specimens the head is black; in one there are irregularly dispersed gray dots on the dark ground color. In both the dorsum is uniform brown. The venter is grayish white in preservative. The snakes retained the same ventral coloration in life. Only the lateral edges of the ventrals possess an encroachment of gray which is more pronounced posteriorly. The caudals are light gray. To our knowledge this subspecies has not been recorded previously from the state of Coahuila, although known from Nuevo León, near the border of Coahuila in the eastern Sierra Madre.

Crotalus molossus nigrescens Baird and Girard. Two males, KU 39568-69, were collected by R. W. Dickerman 5 miles southeast of Ocampo and San Marcos.

The following scutellation data are evident: scale rows, 27-27-19, 31-29-21; ventrals, 185, 179; supralabials, 18-18; infralabials, 18-18.

The scale counts are typical of *nigrescens*, but the coloration is nearer that of *molossus*. The snout is slightly darker than the occiput. The scales bordering the lateral extensions of the dorsal blotches are narrowed laterally; they are present on most of the body. Klauber (1952, Bull. Soc. Nat. Hist. San Diego, 26: 90) states that the subspecies *nigrescens* can be distinguished from *molossus* by the higher number of scale rows, supralabials and infralabials. We have assigned these specimens to *nigrescens* on morphological criteria, although cognizant of the trend toward *molossus* in coloration.

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Secondarily Ingested Food Items in Snakes

By WILFRED T. NEILL AND E. ROSS ALLEN

An interesting article on the feeding habits of snakes enumerated the stomach contents of four crotalid species in the Columbus, Georgia, area (Hamilton and Pollack, 1955, Nat. Hist. Misc. No. 140: 1-4). It was concluded that the pygmy rattlesnake, *Sistrurus m. miliarius* (Linnaeus), preyed heavily upon centipedes, since these arthropods were present in four out of twelve food-containing stomachs. However, is it not possible that the centipedes had been eaten by, say, race-runners, *Cnemidophorus sexlineatus* (Linnaeus), which were in turn fed upon by pygmy rattlers? In such cases the normal prey, the lizards, might be digested, leaving the chitinous arthropods relatively untouched by the snakes' digestive juices. Some frogs, salamanders and lizards will feed upon centipedes, swallowing these arthropods entire, mashing them a little in the process but otherwise leaving them intact. Pygmy rattlers are well known to prey upon small amphibians and reptiles.

Of course, one cannot be dogmatic in the case of the pygmy rattler, which may really be found to eat centipedes. However, snakes unquestionably are left with secondarily ingested arthropods when the primary vertebrate prey has been digested. This was the case with the red-bellied water snake, *Natrix e. erythrogaster* (Forster), at a locality near Augusta, Richmond County, Georgia. Here these snakes preyed upon toads, *Bufo terrestris* Bonnaterre and *B. woodhousei fowleri* Hinckley, which in turn were feeding upon small beetles. Upon dissection, some of the snakes were found to contain toads, which were virtually packed with beetles; others contained toads partially digested, so that a few of the secondarily ingested insects were free in the snake's digestive tract; one at first glance appeared to hold only insects, although close examination revealed the nearly digested remnant of a (presumed) toad; and in three snakes only beetles were found. The chitinous arthropods defied digestion, and remained in the snakes' digestive tract after all traces of primarily ingested prey had disappeared. If the locality had been visited but once, and only one or two snakes collected, dissection might have suggested that *N. e. erythrogaster* was insectivorous.

The junior author once found a number of beetles in the stomach of an indigo snake, *Drymarchon corais couperi* (Holbrook), but believes they were secondarily ingested since this reptile preys upon vertebrates including insectivorous frogs. Just occasionally, crayfish fragments are found in a red-bellied water snake or a Florida banded water snake, *Natrix sipedon pictiventris* Cope; these chitinous remains could possibly represent only the stomach contents of fishes that fell prey to the snakes. (Some species of *Natrix* definitely eat crayfishes.)

Hamilton and Pollack (*op. cit.*) found a mantis, a locust and a caterpillar in the stomachs of copperheads, *Ancistrodon c. contortrix* (Linnaeus), and thought they were "of primary origin, since no other food accompanied these remains in the stomach." However, the absence of other remains is no proof that the arthropod items were primarily ingested. (There does appear to be some evidence that the copperhead is insectivorous at times.)

The so-called elephant-trunk snake, *Acrochordus javanicus* Hornstedt, is thoroughly aquatic, inhabiting mangrove swamps and other coastal waters. Its food has been given as "water beetles and fruit" (De Rooij, 1917, The Reptiles of the Indo-Australian Archipelago. II. Ophidia: 43). How much more likely that a specimen digested a fish but not the insect and plant material that the fish contained. It has been claimed that the little-known aquatic snake, *Herpeton tentaculatum* (Lacépède), feeds upon algae, but here again secondary (or perhaps accidental) ingestion seems more likely.

It is possible that certain vertebrate remains from snake stomachs were secondarily ingested. Frequently, such remains are not viewed in place; the digestive tract is removed, opened, and its contents emptied into a pan of water. Usually the macerated material would all be taken for food items captured by the snake. The brown water snake, *Natrix t. taxispilota* (Holbrook), feeds almost entirely upon fishes; in captivity, if it feeds at all, it will accept only this prey. Catfishes seem to predominate in the brown water snake's diet, and very large ones are often taken. There have been one or two reports of frog remains from the stomach of *N. t. taxispilota*, but it is not improbable that the frogs had been gulped down by catfishes.

Most workers are doubtless familiar with the digestive process in snakes; nevertheless, this process might be summarized briefly. The snake's prey, often a relatively large animal, is swallowed whole; it is usually digested in its entirety, except for enamel-covered teeth, heavy bone, and sometimes claws, beaks, thick fur or feathers. Elimination of waste may take place the day after feeding, or may be delayed for more than two months (Oliver, 1955, The Natural History of North American Amphibians and Reptiles: 188); even then it is not necessarily complete. The length of time required for elimination is affected by the size of the prey, its nature, and the temperature to which the snake is exposed during digestion. Hard parts of the customary prey may remain in the snake's digestive tract long after the softer parts have vanished, and this is true also of secondarily ingested items—hard or soft—to which the snake's digestive enzymes are not adapted.

Evidently, an indigestible item may remain for several months in a snake's digestive tract. A large, captive reticulated python, *Python reticulatus* (Schneider), at the Reptile Institute once voided the upper and lower alveolar ridges of a tortoise. The snake had bee nshipped from Siam about three months before, and had refused food since. It subsequently accepted birds and mammals readily, but consistently ignored gopher tortoises, *Gopherus polyphemus* (Daudin). It is suggested that the turtle remains were secondarily ingested along with some carnivorous mammal. On several occasions, both reticulated pythons and Indian rock pythons, *Python molurus* (Linnaeus), kept captive in Siam for an unknown length of time, were shipped to the Reptile Institute where, after three or four weeks, they voided masses of pangolin scales. These scales probably represent the indigestible portion of customary prey, judging from the frequency with which they appear in python scats. An anaconda, *Eunectes gigas* (Latreille), voided the mandibles and teeth of a large dog, along

with a relatively undigested mass of hair. The snake had been received from British Guiana nearly two months previously and had not eaten during that time. Actually, the dog had been eaten an indefinite period of time before the snake was captured. The good condition of the mammal's hair was surprising, and may reflect the fact that the introduced dog is not a natural item of prey for anacondas.

Comparatively little is known about the food of snakes in the wild, and more studies like those of Hamilton and Pollack are needed. However, students should bear in mind the difficulty of interpreting the presence of an unusual item in a snake's digestive tract. The feeding habits of captive examples should throw light on this problem of interpretation. Of course, a captive snake may accept food that it would not encounter in the wild; but in most cases a natural item of diet should not be refused by a snake that is feeding well. In this connection it would be interesting to observe the reaction of a pygmy rattlesnake to a centipede, or of a copperhead to a mantis.

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THE POSSIBILITY OF AN UNDESCRIBED CROCODILE ON NEW BRITAIN.—Apparently there are two phylogenetic lines among the crocodiles of the Southwest Pacific. One of these is represented only by the estuarine crocodile, *Crocodylus porosus* Schneider, found from southern Asia to northern Australia. Deraniyagala (1939, The Tetrapod Reptiles of Ceylon, Vol. 1: 344) would place this gigantic reptile in a monotypic genus, reviving Gray's generic name Oöpholis. As its common name suggests, *C. porosus* is characteristic of estuaries and the lower reaches of streams. The other line is represented by a number of smaller crocodiles, each somewhat restricted in range. Thus, *C. johnsoni* Krefft is confined to northern Australia, *C. n. novae-guineae* Schmidt to New Guinea, and *C. n. mindorensis* Schmidt to Mindoro, Luzon, Mindanao, and the Sulu Archipelago. The last two species were described by Schmidt (1928, Field Mus. Nat. Hist., Zool. Ser., 12: 175, *ibid.*, 1935, 20: 68), who has also remarked that another member of this group may some day be found in the ancient lakes of the Celebes (*ibid.*: 70). This same line appears to be represented in Indo-China, Thailand, Java, and the Malay Peninsula by *C. siamensis* Schneider; in India by *C. p. palustris* Lesson; in Ceylon by *C. p. kimbula* Deraniyagala; and in Borneo by a crocodile whose identity is uncertain. Elsewhere I have shown that *C. n. novae-guineae* is palustrine, and thus ecologically separated from *C. porosus* (Neill, 1946, Copeia 1: 17). It also occurs in lakes of the New Guinea hinterland, where the estuarine crocodile has not been taken. The habits of *C. johnsoni* and *C. n. mindorensis* are not well known, but both species also appear to be somewhat separated ecologically from *C. porosus*. The Asiatic *C. siamensis* and *C. palustris* have been reported chiefly from freshwater swamps, although the latter occasionally invades salt lagoons on Ceylon.

In recent years it has become evident that many Southwest Pacific islands harbor some palustrine crocodile in addition to the widespread estuarine species. The phylogenetic line that includes *Crocodylus n. mindorensis* and *C. n. novae-guineae* is apt to be found on yet other islands, especially the larger and older ones. The present note suggests that a crocodile, other than *C. porosus,* inhabits New Britain. The suggestion is offered very tentatively, but on something more than biogeographic grounds.

New Britain, largest island of the Bismarck Archipelago, is about 370 miles long. A rugged chain of high mountains extends from one end of the island to the other. Several peaks exceed 6,000 feet in height; some, on the Gazelle Peninsula, reach 7,900 to 8,000 feet, according to recent surveys. The interior is not well known, and much of it was mapped for the first time during and since World War II (see Krieger, 1943, Smithsonian Institution War Background Studies, No. 16: 67). While serving with the U. S. Army Air Forces in the Pacific during that war, I once flew over New Britain. From the air I observed a number of crocodiles, the largest about eight or nine feet long, around the margins of upland lakes. Circumstances rendered it impossible to spend any time in investigation; but at one point the plane passed so low over a lake that a crocodile was frightened into the water, and I could see it plainly. I also noted that the plane was at an altitude of approximately 1,400 feet. Some weeks thereafter I heard a lecture on jungle survival, given by an officer who had been forced down in the interior of New Britain and had eventually made his way to safety. He mentioned having seen crocodiles about the lakes of the island; he thought he had observed them as high as 4,000 feet but could not be certain as to this. According to him, these crocodiles were shy, fleeing into the water at his approach.

I have collected and observed *Crocodylus porosus* in several portions of its range; have had some experience (recounted elsewhere) with *C. n. novae-guineae;* have seen a few *C. johnsoni* in the wild; and have visited localities for *C. n. mindorensis* on Mindoro and Luzon. While a positive statement is not justified, I feel that the New Britain lake crocodiles probably are not *C. porosus;* they are much more apt to be either *C. n. novae-guineae* or an undescribed relative thereof.

It is true that the estuarine crocodile follows rivers upstream to points well above the tideway, as pointed out long ago by Dubois (1896, Notes Leyden Mus. 18, Nos. 2-3). In Australia it has been observed more than 50 miles above the coast (Barrett, 1950, Reptiles of Australia: 12). Schmidt (1932, Field Mus. Nat. Hist., Zool. Ser., 18: 172) reported the collection of a specimen 65 miles up the Sepik River of New Guinea, and measured a skull at a native village nearly 250 miles from the coast. However, the interior tribes of New Guinea highly prize various items of coastal produce, which they somehow manage to obtain (see Stirling, 1943, Smithsonian Institution War Background Studies, No. 9: 16). Even among the mountain peoples I have seen large marine shells and slabs of mother-of-pearl. Animal skulls, often displayed about native longhouses, are not necessarily of local origin, and it cannot be inferred that the estuarine crocodile ranges 250 miles inland. In any event, the rivers of New Britain are relatively small and swift, hardly suitable for *Crocodylus porosus.*

Some New Guinea tribes are well aware that two species of crocodiles occur on their island, one being large, dangerous, and of fluviatile habitat, the other smaller, innocuous, and frequently palustrine. On several occasions I have watched a native enter the shallows of a river in an area where *Crocodylus porosus* occurred. He would proceed carefully, spear at the ready, glancing to right and left, and roiling the water surface as little as possible. In contrast, the tribes of the interior, who have only *C. n. novae-guineae* to deal with, stage crocodile hunts, actually wading into drying lakes and driving the reptiles before them. Thus it seems fairly clear that the estuarine crocodile is lacking from the upland lakes of New Guinea, whether or not it occurs in the rivers; and a similar situation should prevail on the adjacent island of New Britain.

I had hoped that other returning servicemen would bring back more precise information or even specimens of the New Britain lake crocodile; but the hope has not been realized, and it seems desirable to offer this note, inconclusive though it may be.—*Wilfred T. Neill, Research Division, Ross Allen Reptile Institute, Silver Springs, Florida.*

THE MUSK TURTLE IN IOWA.—Three Kinosternid turtles from Muscatine County, Iowa, have been identified as Musk turtles, *Sternotherus odoratus* Latreille, and appear to be the first recorded examples of this genus from the state. Lack of previous Iowa records can be attributed to the paucity of systematic collecting. The nearest record of this turtle is Rock Island Co., Illinois (Cahn, 1937 Ill. Biol. Mon., 16:50, map 3) which is only 40 miles from the Iowa locality.

All the Musk turtles in the writer's collection are females. They were found on June 17 and 25, 1955, in a spring-fed ditch 7 miles west of Muscatine, Iowa. The ditch was characterized by deep, clear water and abundant aquatic vegetation. Similar ditches surround the one described, but the turtle has been found only in one thus far. One of the females laid six hard shelled eggs in captivity on July 5, 1955. The eggs were placed in a porous clay container to develop. On August 31 one of them, when opened, was found to contain a near-hatchling. Four others hatched on September 14 and 15. Length and width of carapace (in mm.) in three adults and four hatchlings are as follows, respectively: 108, 77; 103, 77; 80, 59; 24, 19; 23, 18; 22, 19; 22, 17.

Although only one colony of Musk turtles has been discovered in Iowa, the numerous backwaters and overflows of the Cedar and Mississippi Rivers form such an inviting habitat that probably more colonies exist in this area.

Since the above note was written, the writer made a short survey of reptile life 20 miles south of the above mentioned Musk Turtle site. In one day 38 specimens of the Illinois Yellow Mud Turtle, *Kinosternon flavescens spooneri* Smith, were seen. This turtle was added to the Iowa herpetofauna in 1955 by Dodge and Miller. These two turtles are the only Kinosternids known to occur in Iowa.—*Christopher H. Dodge, 430 N. Linn St., Iowa City, Iowa.*

Comparisons of Two Species of Salamanders, *Plethodon cinereus* and *Plethodon dorsalis**

By GORDON R. THUROW

Although *Plethodon dorsalis* Baird and *P. cinereus* (Green) are widely known forms there has been continued difficulty in distinguishing the two as separate species. This is indicated by varying terminology in the literature, misidentifications, particularly of mixed series, and has been brought out in conversation with various field workers.

The following list of criteria is an abstract of more detailed studies of the two species. Application of these criteria, plus other information, has necessitated a change in specific allocation of the subspecies hitherto known as *Plethodon cinereus angusticlavius* Grobman, now regarded as *Plethodon dorsalis angusticlavius* Grobman (new comb.).

The characters listed here have been derived from the personal examination of over 6,000 living and preserved *cinereus* and between 500 and 1,000 *dorsalis*, from all parts of their ranges, and have been tested repeatedly, particularly with Indiana material. Most of the characters have been previously mentioned by one author or another, but working knowledge of more than a few characters does not seem to be widespread.

Character List

1. *Tail length and shape. Dorsalis* has a shorter tail than *cinereus*, and it is more noticeably tapered, so that its mass relative to the total mass of the animal is much less. Although the tail length of *dorsalis* may exceed the head and trunk length, it very rarely exceeds the length from the snout to the posterior margin of the vent, while the unregenerated tails of adult *cinereus* exceed this length widely, often by 10-20%, and sometimes by almost 30%. Some dwarfing of *P. c. serratus* makes these tail differences less marked, and the tails of Georgia *cinereus* are not thus elongated.

2. *Costal grooves.*—This character is not reliable for all individuals, since *cinereus* varies from 15-20 over its range (see Bleakney, 1952, Canadian Field Naturalist, 66: 125-129) and *dorsalis* varies from 17-19 (I tend to get one more groove than Bishop (1943, Handbook of Salamanders), many specimens giving 18½ on the long count). However, in most areas where both species are found the condition in *dorsalis* varies around 17 complete folds, and the variation in *cinereus* centers on 18 complete folds, or intercostal spaces, and the majority of a mixed series can be distinguished.

3. *Costal folds between adpressed limbs.* I do not favor the use of this character. It cannot be taken accurately from a live squirming salamander, the limbs stretch in anesthetized specimens, and they may break in preserved ones. The character has been shown to vary with age and sex, younger specimens and males giving shorter counts. There is too much variation for the character to be reliable in identifying *individuals* of closely related species. The count is usually 6 or 7 in adult *dorsalis*, although young males may have 5 and old females may have 8. In *cinereus* the count is usually 7 or 8 full costal folds, and rarely 9.

*Contribution No. 582 from the Zoological Laboratories of Indiana Univ.

4. *Mouth characters.* There appear to be no strong mouth characters to differentiate these two species. The aspect of the mouth seems somehow different in most specimens, but individual characters break down. Vomerine tooth counts vary from 4-8 per row in both *cinereus* and *dorsalis* (except in rare aberrant specimens in which there is a continuous vomerine-parasphenoid toothed area—seen in *cinereus* but not *dorsalis*) with 5 and 6 commonest, and others have found that the counts do not differ significantly (Grobman, 1944, Ann. N.Y. Acad. Sci., 45: 261-316). The tongue appeared to be smaller and narrower in most *cinereus,* and Bishop (*op. cit.*: 234, 237) gives this as a difference. However, continued examination revealed large and small tongues in both species, and comparison with live specimens indicate that both have a large tongue but that its size and shape may be altered by preservation. Superficially, the gap between vomerine and parasphenoid teeth appears to be about equal to or greater than the length of a vomerine row in *dorsalis* and less than that in *cinereus.* Repeated binocular examinations reveal that the gap is usually about equal to or greater than a vomerine series length in both species, although animals in which the gap is less are usually *cinereus.* More *cinereus* appear to have the anterior ends of the parasphenoid patches narrowed and in close contact, but this cannot be relied upon.

Two characters which appear to show some real average difference are the slant of the vomerine teeth rows and the thickness of the jaw margin. The degree to which the vomerine rows curve backwards is difficult to measure objectively, but repeated comparisons show that the general appearance usually gives the impression of about a 45° slant in *cinereus* and markedly less than this in *dorsalis.* The gross vomerine-parasphenoid teeth pattern is frequently a "T" in *dorsalis* and an "X" in *cinereus.* I think about 75% or more of mixed material can be separated correctly by this character, after it becomes familiar.

The thickness of the premaxillary part of the jaw margin, the shelf of tissue containing the teeth, appears relatively and absolutely wider in *cinereus.* Ocular micrometer measurements of four females and three males of each species give a range of 17-22 units (.46-.59 mm.) and an average of 19 units for *dorsalis,* and a range of 25-28 units (.67-.76 mm.) and an average of 26 units for *cinereus.* There is undoubtedly overlap, particularly between male *dorsalis* and female *cinereus,* since the margin appears to be a little thicker in males. Again perhaps about 75% of mixed material can be correctly assigned with practice. The arch of marginal teeth seems somewhat broader and more flaring in *dorsalis,* with less angularity at the nares, but this is hard to measure.

5. *Male premaxillary teeth.* In *cinereus* these are enlarged so they can be felt by stroking the mentum. In *dorsalis* they are not enlarged, and are rarely felt (except in rather dehydrated specimens). These differences are seen quite strikingly under the binocular, the uniform *dorsalis* tooth-row contrasting with the occasional dagger-like enlargements in the *cinereus* row.

6. *Male snout.* The greater swelling of the naso-labial groove areas in male *cinereus* gives them a more truncate snout than *dorsalis* or female *cinereus.* Micrometer measurements show that the snout-to-eye length of male *cinereus* is slightly longer, if anything, than the length in *dorsalis* or female *cinereus,* and that the truncate shape is caused by the outward

swelling of the narial areas rather than by shortening. This puts "shoulders" on the snout outline, changing it from the usual parabola to a box-like shape. Micrometer measurements of the internasal distance confirm that it is larger in male *cinereus*. And this measurement does not fully indicate the difference, since the nares face forward in male *cinereus*, rather than outward as in *dorsalis*. That is, the backward slant of the snout outline begins at about the medial edge in *dorsalis*, but laterad of the nares in male *cinereus*. After the snout shape and narial orientation become familiar under the binocular, measurements are unnecessary. Only adult animals of similar size should be compared.

7. *Mental gland*. Both the shape and size differ. In (male) *dorsalis* the gland (really a pad formed by many swollen glands) is small and round, and widely separated from the jaw rami. In (male) *cinereus* the glandular area is about 1½ to 2 times as large, and has the outline of a gumdrop or igloo. The convex side is closely adjacent to the jaw rami and the glandular patch largely fills the mental area. The patch is wider than long in *cinereus*, and either a circle or a longer-than-wide oval in *dorsalis*.

8. *Ventral hedonic glands*. These enlarged glands occur typically on the ventrum of *Plethodon*, and produce an orange or gold colored mucus-like secretion when active (this quickly fades to white in preservative). I have previously described their distribution on *Plethodon* (MS, 1951, and 1956, Amer. Midl. Nat., in press). Although all the secondary sex characters given here (with the possible exception of the premaxillary teeth) vary in prominence seasonally, most salamanders are taken during the sexually active season so the characters can usually be compared. The glands appear to get slightly larger in many (male) *P.c. cinereus* than in (male) *P.d. dorsalis*, micrometer measurements indicating a diameter of about .3 mm. as to .2 mm. In gross aspect, they are noticeably more conspicuous on the tail ventrum of *cinereus* than on that of *dorsalis*, and more consistently present. The sexes cannot be as dependably separated by this and other secondary sex characters in *dorsalis*, and there are more suggestions of intersexes. A few *dorsalis* which otherwise appear to be females seem to have weakly developed hedonic glands (this is difficult to tell because the ordinary mucus glands are more enlarged on the tail ventrum), and many males with well developed mental glands simply do not show hedonic glands. Some *dorsalis*, and more rarely *cinerus*, have hedonic glands all over the belly and even on the gular region, tending towards the apparently more primitive condition found in the eastern large *Plethodon*. Regional variation occurs in both species, and is more marked in *cinereus*. Georgia specimens of *cinereus* appear to have few or no hedonic glands although otherwise sexually active, and *P.c. serratus* has less development than *P.c. cinereus*, only two rows of small glands being characteristic. *P.d. angusticlavius* has little or no development, being perhaps still weaker in this regard than *P.d. dorsalis*.

9. *Dorsal pattern*. The characteristic wide straight-edged (or finely serrate) band of *cinereus* with longitudinal trains of small black flecks, and the typically lobed (at least on the anterior part) and more irregularly flecked band of *dorsalis* are easily separated. In all but a few of the variously melanistic *dorsalis* traces of the lobed band can be seen, and the other pigment characters below separate these from the usually darker and uniformly black *cinereus*. Some of the dark *dorsalis* material from

south central Kentucky and central Tennessee is especially difficult, but here the locality is an aid. Some *dorsalis* have a straight-edged stripe, but it is narrower than the stripe of all but a very few aberrant *P. cinereus*. The stripe becomes narrower on the tail of *cinerus*, while in narrow-striped *dorsalis* (particularly *P.d. angusticlavius*) it is wider on the proximal part of the tail than on the back.

10. *Rostral band*. Although most *dorsalis* and *cinereus* have the stripe partially obscured on the head, it reappears again on the anterior face of the snout in most *dorsalis*, forming a narrow vertical stripe or spot. This is quite conspicuous in most *dorsalis* and rather rare in *cinereus*, where the snout is usually dark or at least uniform (a few populations do have the stripe). This character is still conspicuous after color fading in preservative. It is not useful west of the Mississippi, since *P.d. angusticlavius* lacks the spot. It is present but poorly developed in some *angusticlavius* from southwestern Illinois.

11. *Ventral "orange" pigment* (*live specimens*). *P. dorsalis* has orange pigment mottling all over the body, including the ventrum, while all the presently described subspecies of *cinereus* have the orange pigment restricted to the dorsum and upper flanks except just anterior to the forelimbs where it may descend to the lower flanks. It may even pass onto the pectoral area in rare aberrant *cinereus*. This apparently occurs normally in some yet undescribed *cinereus* populations located outside the range of *dorsalis* (personal communication, A.B. Grobman), but even these lack orange pigment over all the belly.

12. *Color of the "orange" pigment* (*live specimens*). Although this pigment varies from yellow through deep red in both species, there are differences which are helpful in the areas of range overlap. In Indiana and Illinois *dorsalis* is more variable, many specimens being various shades of yellow and orange, while the great majority of *cinereus* vary narrowly around the typical brick-red or orange-red shade. In the southern Appalachians the situation is reversed, *cinereus* varying widely and commonly exhibiting such aberrant colors as "pale peach," chartreuse, and yellow, while *dorsalis* is almost always red and frequently so melanistic that the color is obscured.

13. *Ventral mottling*. Although overlapping, the belly pattern of the two species is characteristically different, and with practice most specimens can be separated by this character. As indicated by Bishop's 1943 photographs the black and white pigment is not separated into such large aggregations in *dorsalis* as it is in *cinereus*, but remains in scattered small spots mixed with orange spots. The contrast is consequently much sharper in most *cinereus*. A better character, particularly with preserved material, is the anterior-posterior change in mottling, as shown by the spacing of the remaining black pigment. In *cinereus* there is usually a continuous increase in spacing anteriorly (especially from mid body), resulting in a relatively very light gular area. In *dorsalis* the belly becomes lighter anteriorly, often with a marked area of extensive spacing from about the forelimbs to the gular fold, and then the gular area becomes darker again, although not so dark as the belly. With good preserved material the correct light will reveal extensive guanophore remains in the pectoral gaps of *cinereus* and large areas lacking this pigment in the pectoral gaps of *dorsalis*.

14. *Gular pattern* (*best seen in life*). Most *cinereus* have a heavy aggregation of white pigment on gular area, so that the gross impression is that of a white gular zone margined sharply by black lips, something like the margining of *Pseudotriton ruber schencki.* This margining is not developed in juveniles, and is sometimes faded in males. The gular zone of *dorsalis* is not greatly different from the rest of the ventrum (although there is often more orange pigment on the gular and pectoral region), and there are no contrasting black lips.

15. *Lateral guanophore pigment* (*not useful in badly faded specimens*). The differences here are easier to recognize than describe, and there is overlapping. They are most helpful in the melanistic specimens. As on the ventrum, *cinereus* has much heavier aggregates of pigment on the lower flanks, often appearing as large white or cream and gray colored spots, or even a more or less continuous mass, extending forward to merge on the gular region. The ventrolateral white spots of *dorsalis* are usually much smaller, although the total concentration of white pigment is also usually heavier than on the belly. The species difference is most marked on the cheek. Although both species may have a frosting of very small gold or silver (iridescent) flecks on the dorsum in life, in addition to small scattered white spots, and *cinereus* may have more guanophores on the tail, there is one extensive mottled pattern which is characteristic of *dorsalis.* Silver frosting (still visible in many preserved specimens) alternates with large non-frosted chocolate areas on the dorsum and upper flanks of the tail. This pattern is best shown in the melanistic *dorsalis,* and in some parts of Kentucky and Tennessee this chocolate and silvery form seems to assume the nature of a definite color phase.

Additional characters were sensed intuitively, such as a general difference in the body outlines and the facing view of the head, and after familiarity, the "gestalt" of the particular species could be recognized at a glance. These were not demonstrated objectively, however, and some were flatly contradicted by measurements. *P. cinereus* attains a larger size than *dorsalis* but this is not a useful character. There are only a few internal differences other than those indicated by the above characters, as the two forms are actually very closely related. Some preliminary investigation seems to indicate that there are more differences in histology than in gross internal anatomy.

The four secondary sexual characters can be correlated with the stronger sexual dimorphism in *cinereus.* Six of the seven pigment characters can be grouped as due to greater aggregation of the guanophores in *cinereus,* more restricted distribution of the orange pigment, and different arrangements of the melanophores. There appears to be quantitatively more black and white pigment and less orange pigment in *cinereus.*

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BRADDOCK HEIGHTS, MARYLAND.

THE LEOPARD FROG *RANA PIPIENS SPHENOCEPHALA* IN SOUTHEASTERN PENNSYLVANIA.—The range of *Rana pipiens sphenocephala* Cope, as stated by Schmidt (1953, Check List N. Amer. Amphs. Repts.: 82) includes the Atlantic Coastal Plain. Due to a paucity of study material this frog has not been recorded as occurring in Pennsylvania. Field work along the coastal plain of southeastern Pennsylvania in April of 1952 and 1953 resulted in the collecting of sixty-one *sphenocephala* near Bristol, Bucks County. The presence of this frog in Pennsylvania is reported here with summarized notes on the habitat and morphology of the specimens.

The coastal plain in Bucks County is adjacent to the Delaware River and is a narrow strip, one to two miles wide, of level land. The elevation varies from five to twenty feet. Coastal plain deposits overlap the adjoining Piedmont formations so there is a transition zone rather than a marked distinction between these two physiographic entities. Gravel and sand excavations have left many permanent depressions which, when filled with rain water, serve as amphibian breeding sites. It was in such a situation that the study material was collected.

For purposes of comparison, sixty-one *Rana pipiens* from western Pennsylvania, New Jersey, and Delaware were borrowed from the Carnegie Museum and Mr. Roger Conant. It has been difficult to make correlations with published data due to the failure of authors to cite specific localities and the inconsistency of the diagnostic characters employed. The examination of all the material showed the following characteristics to be inconsistent and of little value: extension of the dorsolateral folds into the supraocular region; pigmentation on the posterior surface of the femur; and the presence of a longitudinal bar on the anterior surface of the femur. There follows a discussion of those characters which have been regarded as significant for the identification of *sphenocephala:* acuteness of snout; tympanic spot; dorsal spots; lateral spots; and crossbars on the shank.

The acuteness of the snouts is difficult to express through linear measurements. However, all the coastal plain specimens were distinguished by sharply-pointed snouts.

Conspicuous white tympanic spots have been reported as being usually present on *sphenocephala.* On the recently acquired material such spots were present on 88.5% (of which 5% have only one tympanum spotted) and absent on 11.5%. The vividness of the white spots was most apparent when the frogs were collected at night, for they could be easily discerned on some individuals from a distance of six feet. Notes made at the time of preservation showed them to vary from large and conspicuous to small and faint on four specimens.

The spots on the dorsum between the dorsolateral folds were found to average twenty, range ten to twenty-eight. Their size tended to be small and only infrequently circular in shape. In many cases they were distended on the longitudinal axis.

Lateral spots were quite distinct, scattered, and circular or oblong in shape. They did not tend to form a reticulum as is the usual case in the subspecies *pipiens*. The mean was nine and range two to twenty.

It is of interest to note the absence of complete cross-bars on the shank of most individuals. On the Bucks County specimens they were only present on 34% and then at a maximum of one bar.

Extensive collecting throughout eastern Pennsylvania indicates *sphenocephala* occurs only in isolated localities now undergoing modifications due to industrial expansion. It is still too early to determine the ultimate effects of this industrial growth along the Delaware River on both the flora and fauna. Many former collecting sites are being drained and/or filled. Housing projects such as Fairless Hills occupy 1250 acres and Levittown 3000 acres. Sphagnum bogs, marshes, and water-filled excavations have been eliminated.

The restricted range of this frog in Pennsylvania is not unusual since previous works on the biota have included remarks on many forms which occur only along the coastal plain. Benner (1932, The Flora of Bucks County, priv. printed: 5-331) cites eighty-four "notable examples" of plants of southern affinities reaching their northern limit here. Also Stone (1910, Rep. N. J. State Mus.: 25-828, pl. I-CXXIV) remarks, "Quite a number of these lowland plants range right up to the fall line, occurring more or less plentiful in Pennsylvania on the strip of land lying between th Delaware River and the fall line . . . . about Bristol and Tulleytown in Bucks County." Conant (1951, Ann. Car. Mus., 32: 281-291, pl. 21) recorded *Pseudemys rubriventris* (LeConte) as a coastal plain inhabitant and cited Dr. Reeve M. Bailey, University of Michigan Museum of Zoology, for information on three fishes as being common and widespread in southern New Jersey but restricted to the coastal plain in Pennsylvania.

The writer is aware of the controversy over the subspecific recognition of *sphenocephala*. However, I concur with Schmidt (1950, Texas Journ. Sci. 326-334) who states: "I do not regard the question as to the existence of recognizable subspecific differentiation within the continuous range of *Rana pipiens* as closed." The solution to this taxonomic problem may be resolved after studies of sample populations throughout its range are synthesized. From my studies on these series of specimens I have concluded that the leopard frog inhabiting the coastal plain of Pennsylvania is the form usually referred to as *Rana pipiens sphenocephala*.

Acknowledgements. Mr. Pat Menichini, Philadelphia Zoological Garden, materially assisted in field work. Mr. Roger Conant, Philadelphia Zoological Garden; Mr. James A. Fowler, The Academy of Natural Sciences of Philadelphia; and Mr. Neil D. Richmond, Carnegie Museum, have loaned comparative material, read the manuscript, and offered many helpful comments.—*Robert G. Hudson, Science Department, Northeast High School, Philadelphia, Pa.*

MATING HABITS OF THE GILA MONSTER—On June 4, 1955, two captive Gila monsters (*Heloderma suspectum cinctum* Bogert) were observed fighting over a female, the third occupant of the cage. The smaller individual was removed.

Later in the evening the remaining male was observed copulating with the female. The male had his head pressed down on top of the female's neck, while the trunks of the bodies were slightly separated from each other. The left leg of the male was over the base of the female's tail, and his left hand was crossed over the base of that of the female. The cloacas were in juxtaposition with most of the torsion being supplied by the male's body. (See Fig. 1.) Copulatory movements were in slow, convulsive movements occurring every three or four seconds. The mating lasted nearly a half hour.

The same Gila monsters were again observed mating in identical positions on June 9 and on September 30, 1955.

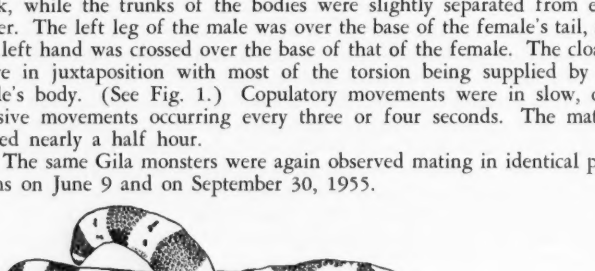

Fig. 1. Mating position of *Heloderma suspectum cinctum*. Male is in upper part of diagram. Adapted from a photograph.

Unfortunately the female died on November 2, 1955, and was not discovered until two days later. Upon examination it was found that she contained five well developed eggs, all of which were dehydrated except one, this measuring 26.8 mm. in length by 14 mm. in diameter.

Literature records of the Gila monster's habits of mating and reproduction data are scarce. Hensley (1950, Trans. Acad. Sci., 53(2): 268) reports five large and 25 smaller unfertilized eggs taken from one female. This individual was captured in May, but at the time of preservation in October the eggs had not been laid. The larger eggs ranged in size from 35 mm. to 37 mm. in diameter, the smaller ones varying from 1 mm. to 7.5 mm.

In my own records are data on three females, two collected in April and the third in May, containing 40, 47, and 52 undeveloped eggs, respectively, the largest egg measuring 5.5 mm. in length. Stebbins (1954, Amphibians and Reptiles of Western North America: 306) states that the eggs have soft, flexible shells and are about 60 mm. to 72 mm. long when laid.—*Gerald O. Gates, Wickenburg, Arizona.*

Two New Salamanders of the Genus *Plethodon* From the Southeastern United States

By Richard Highton and Arnold B. Grobman

In the eastern United States, speciation among the small plethodons has been almost as extensive as that among the larger ones. Only in recent years, however, has the variation in these salamanders been investigated. Several available collections include two apparently new forms of the genus *Plethodon*. One, a race of *Plethodon cinereus*, is represented by specimens from the Piedmont of Georgia. The other confirms the suggestion made by Grobman, (1949, Proc .Biol. Soc. Washington, 62: 139), that a new flecked *Plethodon* of the *richmondi-nettingi-welleri* group might be found in the southwestern Virginia mountains.

As a result of vertebral counts made by Highton with X-ray equipment, we are able to give a more precise description of these forms than would be possible using traditional costal groove characters. It will be demonstrated in a future paper that the number of costal grooves (including those in the axillary and inguinal regions) is normally one less than the number of trunk vertebrae. By trunk vertebrae we refer to those lying between, but not including, the cervical vertebra and the sacrum.

For the loan of specimens we wish to thank Mr. Arthur Loveridge, Museum of Comparative Zoology (MCZ); Dr. Doris M. Cochran, United States National Museum (USNM); Mr. Ralph Dury, Cincinnati Society of Natural History (CSNH); and Drs. Norman Hartweg and Charles F. Walker, University of Michigan, Museum of Zoology (UM MZ). Other institutions in which type material has been deposited are: Academy of Natural Sciences of Philadelphia (ANSP); American Museum of Natural History (AMNH); Carnegie Museum (CM); Chicago Academy of Sciences (CAS); Chicago Natural History Museum (CNH M); Museum of Vertebrate Zoology (MVZ); and University of Florida (UF). Dr. John W. Crenshaw, Jr., was the first to collect the new Georgia form in numbers and it is mainly through his efforts that sufficient specimens are available for our definition; 22 specimens in his personal collection (JWC-FC) are designated as paratypes. All available specimens have not been made paratypes since some had questionable locality data or were poorly preserved. For some designated paratypes accurate vertebral counts could not be obtained from the radiographs. For these reasons the number of individuals in the tables and in the list of paratypes will not be identical.

The form in Georgia has a higher number of vertebrae than the typical race and may be designated:

Plethodon cinereus polycentratus, new subspecies

Holotype. UF 8376, an adult male of the red-backed phase, collected 2 miles northeast of Palmetto, Fulton County, Georgia, on February 2, 1954, by Albert H. Highton and Richard Highton.

Description of the holotype in life. Length: snout to anterior angle of vent, 40 mm.; snout to posterior angle of vent, 43 mm.; total length, 80 mm. Vomerine teeth, 5 on each side. 22 trunk vertebrae. 21 costal grooves. Color (Villalobos and Villalobos, 1947, Atlas de los colores,

Buenos Aires: 1-74, pls. 1-38), red dorsal stripe (SSO 8-8°); ground color lateral to red dorsal stripe (SSO 5-1°). Scattered red pigment also present on top and sides of head, on all four limbs, on ventral surface between front limbs, and on the sides of body and tail. Venter mottled with yellowish-white guanophores. Smaller white guanophore spots scattered over dorsal and lateral surfaces of body and tail.

Paratypes. (All from Georgia) UF 8377-91, topotypes, same date and collectors as the holotype; JWC-FC 649 (15), JWC-FC 762 (4), topotypes, John W. Crenshaw, Jr.; UF 8347 (4), UF 8412 (5), 3.8 miles north of McDonough, Henry County, John W. Crenshaw, Jr.; JWC-FC 784 (3), Decatur, DeKalb County, H. C. Gardner; MCZ 19323, Spalding County, James R. Cain; UMMZ 88575, 3.5 miles east of Summerville, Chattooga County; and UMMZ 113730, 8.5 miles south of Thomaston, Upson County, Philip Marsh.

Diagnosis. A race of *Plethodon cinereus* with a greater number of trunk vertebrae (21-23) than in the other recognized subspecies, which usually have 19 or 20 trunk vertebrae.

Variation in the type series. Our sample contains 34 red-backed specimens and 21 lead-backed individuals. An adult female lead-backed specimen, UF 8377, with the same collection data as the holotype, has a few small red spots on the legs and on the sides of the head and body where they are especially numerous in the costal grooves. There are a few small brassy flecks on the dorsal surface of the head and tail.

Radiographs of specimens of *P. c. cinereus* from several localities in the eastern United States and Canada indicate that the usual number of trunk vertebrae is 20, while in *P. c. polycentratus* there are usually 21 or 22 trunk vertebrae (see Table 1). There is only slight overlap in the number of trunk vertebrae in the available specimens of the two forms; 91% of our material can be correctly assigned using the key couplet, 21 or more trunk vertebrae = *polycentratus,* 20 or less = *cinereus.*

Table I. The number of trunk vertebrae in samples of *Plethodon cinereus.*

Sample	Number of Vertebrae				
	19	20	21	22	23
P. c. cinereus					
New Brunswick, Canada	3	14	1		
Indiana		6	2		
New Jersey		7			
Virginia	7	33	3		
Eastern Tennessee and western North Carolina	5	40	9		
P. c. polycentratus					
Georgia			21	24	2

Range. P. c. polycentratus is known from the Piedmont of western Georgia (Chattooga, Fulton, DeKalb, Henry, Spalding and Upson Counties). The nearest records of *P. c. cinereus* are in southwestern North Carolina and southeastern Tennessee. No specimens are now known from the region between the records of *cinereus* in the Blue Ridge Province and the Piedmont records of *polycentratus.* The new form is considered

racially related to *P. c. cinereus* because of the close morphological similarity, the slight overlap in the systematic characters, and the apparent geographic replacement.

Two specimens (MCZ 154, 241) labeled "Georgia" possess 20 and 21 trunk vertebrae respectively. They were obtained from a Dr. Jones, who, according to Neill (1948, Copeia: 134), collected in scattered points in north Georgia. They do not create a problem, since the typical subspecies might be expected to occur in northeastern Georgia.

Two specimens from "Dallas County, Georgia" (MCZ 1834), catalogued in 1867, have 20 trunk vertebrae each. There is no Dallas County in Georgia and there was none in 1867, but there is a town of Dallas, in Paulding County. *P. c. polycentratus* might be expected in Paulding County, but because of the uncertainty of the locality data, the accumulation of additional specimens from this county will be necessary before the correct subspecific determination of its population of *Plethodon cinereus* can be made.

The undescribed salamander from southwestern Virginia is intermediate in number of vertebrae between *Plethodon richmondi* and *P. nettingi* and is otherwise similar to them. There is, thus, a series of forms with morphological overlap and geographic replacement. Subspecific rank would seem, therefore, to best indicate their proper systematic relationship. Since *P. richmondi* (Netting and Mittleman, 1938, Ann. Carnegie Mus., 27: 288) was described slightly earlier than *P. nettingi* (Green, 1938, Ann. Carnegie Mus., 27: 295), these two forms should hereafter be referred to as *P. r. richmondi* and *P. r. nettingi*.

Specimens of the new subspecies have been collected in abundance at Comers Rock, southwest of Wytheville, Virginia. Since this salamander was known to Mr. Clifford H. Pope when we found it, and since he has graciously suggested that we describe it, we take pleasure in associating his name with this new form. It is especially fitting, in this fashion, to emphasize the important contributions he has made to our knowledge of the genus.

Plethodon richmondi popei, new subspecies

Holotype. UF 8226, a maturing male, collected at Comers Rock, Grayson-Wythe County line, Virginia, on August 5, 1955, by Arnold B. Grobman and Marc R. Grobman.

Description of the holotype in life. Length: snout to anterior angle of vent, 42 mm.; snout to posterior angle of vent, 44 mm.; total length, 70 mm. (part of tail missing). Vomerine teeth, 5 on each side. 21 trunk vertebrae. 20 costal grooves. Venter dark, with scattered white spots 0.1-0.3 mm. in diameter. Numerous larger (0.3-0.7 mm.) yellowish-white spots on chin. Sides with few small white spots similar in size and appearance to those on the venter. Back heavily sprinkled with tiny (less than 0.1 mm.) brassy flecks and larger (0.1-0.2 mm.) white spots. Brassy guanophores present in the iris.

Paratypes. ANSP 26136-7, AMNH 58375-6, CM 34063-4, CAS 16663-4, CNHM 74868-9, MCZ 28416-7, MVZ 63723-24, UF 8328 (10), UMMZ 113702-3, USNM 137291-2, topotypes, collected by Walter Auffenberg and Arnold B. Grobman; UF 8334 (14), topotypes,

Coleman J. Goin, Arnold B. Grobman, John D. Kilby and Robert Mertens; UF 8005, Locust Cove Creek, 4 miles east of Broadford, Smyth County, Virginia, Leslie Hubricht; USNM 135181-98, Burkes Garden, Tazewell County, Virginia, Richard L. Hoffman; USNM 135199-202, 6 miles west of Wytheville, Wythe County, Virginia, Richard L. Hoffman; USNM 135207-13, Brushy Mountain, 5 miles east of Marion, Smyth County, Virginia, Richard L. Hoffman; USNM 135178, near fire tower on Nigger Mountain, southeast of Jefferson, Ashe County, North Carolina, Leslie Hubricht; USNM 135179, milepost 236.2, Blue Ridge Parkway, Alleghany County, North Carolina, Leslie Hubricht; USNM 135180, 2 miles southeast of Sparta, Alleghany County, North Carolina, Leslie Hubricht; UF 8321-2, near Boone, Watauga County, North Carolina, A. Van Pelt; CSNH 2514 (4), Big Black Mountain, Harlan County, Kentucky, Ralph Dury and Woodrow Goodpaster.

Diagnosis. A southeastern race of *Plethodon richmondi* with fewer (usually 21) trunk vertebrae than in the typical race, which usually has 22 or more trunk vertebrae. It differs from *P. r. nettingi* in having an average of two more trunk vertebrae.

Variation in the type series. The variation in the number of trunk vertebrae in several samples of *Plethodon richmondi* is shown in Table II; 87% of the specimens of *richmondi* and *popei* on hand can be correctly allocated by using the key couplet, 22 or more trunk vertebrae = *richmondi;* 21 or less = *popei.* If our samples are indicative, there is even less overlap between *popei* and *nettingi.*

Table II. The number of trunk vertebrae in samples of *Plethodon richmondi.*

Sample	Number of Vertebrae						
	18	19	20	21	22	23	24
P. r. richmondi							
Cabell County, West Virginia				2	11	1	
Hamilton and Clermont Counties, Ohio				2	19	8	
Allegheny County, Virginia					6	3	1
P. r. popei							
Southwestern Virginia			3	47	11		
Southeastern Kentucky			1	2			
Northwestern North Carolina				2	1		
P. r. nettingi							
West Virginia	1	22	1				

Range. P. r. popei is known from northwestern North Carolina, southwestern Virginia and southeastern Kentucky. This form has previously been referred to by Netting and Mittleman (*op. cit.*: 292), Hoffman and Hubricht (1954, Herpetologica, 10: 192), and Barbour (1953, Copeia: 85) as *Plethodon richmondi.*

These two new forms will be further considered by Highton in a paper on the genus *Plethodon* that is under preparation.

DEPARTMENT OF BIOLOGY and FLORIDA STATE MUSEUM,
UNIVERSITY OF FLORIDA

Ecological Relations of *Rana muscosa* at High Elevations in the Sierra Nevada

By DON P. MULLALLY and JOHN D. CUNNINGHAM

In the Upper Canadian, Hudsonian and Arctic-Alpine Life Zones of the central Sierra Nevada Mountains of California, only four species of ectothermic vertebrates commonly occur, and all are species of amphibians. The one under discussion is the ecologically little known yellow-legged frog, *Rana muscosa* Camp of the higher Sierra Nevada which until publication of recent work by Zweifel (1955) was referred to as *Rana boylei sierrae* Camp. Part of this paper is devoted to a consideration of the body temperatures of active animals, sources of heating and cooling in the environment, and certain habits which are adaptations to meet thermal problems. Information is also included on distribution, activities, and choice of habitat. The material presented herein was gathered during trips through Yosemite National Park and the Humphrey Basin-Granite Park area of Fresno County.

The writers are grateful to Dr. Raymond B. Cowles of the University of California at Los Angeles for critically reading the manuscript and offering many helpful suggestions. Thanks are due Mrs. Katherine Goddard for typing the manuscript.

METHODS

Field observations were made on the frogs and their habitat under a wide variety of conditions and it was possible to become sufficiently familiar with the species so that the exceptional could be distinguished from the usual behavior and normal ecological relationships. The theory, methods, and instruments used in this investigation have been employed in other studies (Cunningham and Mullally, 1956; Mullally and Cunningham, 1956). The basic concepts have been developed from the work of Cowles and Bogert (1944) and from additional information proposed by Dr. Cowles during lectures and personal discussions.

All body and many of the environmental temperatures were secured by means of a small, quick-registering mercury Schultheis thermometer. It was necessary to use other thermometers for registering temperatures above 50° C. Body temperatures were obtained by deep cloacal insertion and only those which were obtained quickly and without prolonged handling or chasing of the animals are presented. No data are included from frogs which, previous to temperature determination, had been exposed to either a colder or hotter environment.

Standard environmental temperatures were taken at sites where the frogs were first seen. Soil surface temperatures were secured by inserting the thermometer horizontally under the soil so that the thinnest possible film of material covered the bulb. Since the thermometer includes more area than the surface film this method provides only a close approximation of the actual surface temperature. At night the exact surface layer will be several degrees colder and under insolation several degrees warmer than the temperature registered by the thermometer. A few approximate rock-surface temperatures are presented, and these were obtained by laying the bulb of the thermometer horizontally against the rock. Temperatures of the ambient air passing close to the animals were taken at heights of ½-1

inch and for comparing with Weather Bureau records at 5 feet above the ground. Close to the ground, the largest source of error in this determination results from exchanges of radiation and conduction between the thermometer and the often superheated or cooled ground surface. All temperatures were taken in the shade, the shade frequently being provided by the investigator's body. Care was always taken to keep the thermometer as far from the operator's body as possible to minimize errors resulting from radiation from the human body. Water temperatures were recorded at a depth of 3 inches or less, depending upon the position of the animals and the total depth of the water.

DISTRIBUTION

Sierra yellow-legged frogs were first encountered and were found very sparingly along Piute Creek at 7700 feet elevation. From this elevation upward they became more abundant. In the Humphrey's Basin area, the densest populations were found above 10,000 feet elevation and a great many, including tadpoles, were noted at and near Pine Creek Pass at an elevation of 11,170 feet. Zonally this pass is Arctic-Alpine on level and shaded slopes, but Hudsonian with white-bark pine (*Pinus albicaulis*) on steep south and west slopes. Several miles to the south of the pass and on the other side of a high divide, frogs were found near timberline at 10,800 feet in Golden-Trout Lake and in the Arctic-Alpine at 11,400 feet and higher around Desolation Lake. Frogs of varying sizes were found along a small stream running northeastward from the latter lake to an elevation of over 12,000 feet, or 500-1,000 feet of elevation into the Arctic-Alpine. Tadpoles were noted in the stream to an elevation of at least 11,600 feet.

Being farther north, Yosemite National Park is cooler and moister than the above mentioned region. Life Zones are thus lower in elevation by an estimated 500 feet, and, since the frogs are not known to occur as high in the north, their distribution seems to reflect this difference. About Tuolumne Meadows and Tioga Pass, yellow-legged frogs are most abundant between the elevations of 9,500 and 10,300 feet. At the Gaylor Lakes, few animals were found at 10,600 feet and none higher. The effect of slope exposure is noticeable. Elizabeth and Johnson Lakes are located in the shaded side of a high ridge to the south and west, and life zones are hundreds of feet lower here than on warmer slopes. Frogs were abundant at Elizabeth Lake (9450 feet) but few occur at Johnson Lake (10,300 feet) near timberline. Frogs were seemingly more plentiful at Johnson Lake in 1950 than in 1955. The cold, snowy winter of 1951-1952 may have had an adverse effect upon the population. This season was the wettest in Yosemite Valley for years, and in protected situations the accumulated snow may have protracted the period of dormancy a lethal period of time for those frogs near their upper elevational limits.

Sierra yellow-legged frogs were also observed at Porcupine Flat (8,100 feet) and elsewhere near the Tioga Road at elevations down to 7,500 fet. Some of the densest aggregations of frogs ever noted were within lakes at about 8,700 feet elevation near Ostrander Lake south of Glacier Point. In 1950 no frogs were found in Ostrander Lake. This lake has many trout, possibly planted, and it is possible that they may be a decimating factor.

HABITAT

As have others (Grinnell and Storer, 1924; Storer, 1925; Zweifel, 1955) we found the Sierra yellow-legged frog to be highly aquatic. Frogs were always within several feet or 2-3 jumps of water. Rocks and logs protruding from the water and the immediate banks compose the terrestrial part of their environment. Inhabited waters include ponds, tarns, lakes, streams, and all but the smallest creeks. Very small creeks of only a few inches depth and width are not often inhabited, especially if they happen to be on steep slopes or are far removed from larger bodies of water. The above notations on restriction of frogs to water and relations to very small creeks closely approximate information given by Zweifel (1955: 221-222) on *Rana boylei* Baird. Water need not be clear to be acceptable. Tadpoles and adults have been found in small, stagnant pools in close proximity to fresh water. In the Yosemite region and along French Creek, such waters frequently have been noted to be reddish colored, probably from iron compounds derived from the rocks. The strong attachment of the species for water partially segregates it ecologically from associated anurans of the Canadian to Arctic-Alpine Zones. The Pacific treefrog (*Hyla regilla*) and the Yosemite toad (*Bufo canorus*) are common in many lush meadows with wet to saturated soil and heavily grown to low, herbaceous vegetation, but the yellow-leg favors such areas only when they border directly upon water.

Although the frogs occur sparingly along the borders of nearly all types of aquatic situations and along a similar variety of shorelines, some preferences are evident. Streams and lakes with margins that gently slope up to a depth of several inches at the shore are the most highly populated while waters which abruptly drop to a depth of 2 feet or more at the shore are rarely inhabited.

At Elizabeth Lake one of the densest aggregations was located at the shallow, southwest end of the lake, particularly around a small, marshy peninsula with tall grasses growing out from it a few feet into the water. However, an inlet of about 40 x 60 feet and uniformly 3-6 inches in depth bordered by a flat, low shoreline grown to low grasses was scarcely inhabited. A few living and an unusually large number of dead tadpoles were noted here, suggesting an anoxic condition. However, the large expanse of very shallow water and grassy, monotonously flat shoreline forms an environmental condition shunned by frogs elsewhere.

The character of the shoreline can be an important factor in local distribution. Long, sandy beaches or steep margins composed of large boulders derived from talus slopes are poorly populated. The beaches have no shelter, and the talus margins generally lack easily accessible perches and shallow depths near shore. Gently sloping shores holding conglomerations of smaller rocks of generally 6 to 24 inches in diameter are abundantly populated. With lakes and streams having various types of shoreline, those portions with the most rocks are always preferred, other factors being equal. Often times frogs are unusually abundant at the rocky outlets of lakes and in the streams extending therefrom. For *Rana boylei*, Zweifel (1955: 221) emphasized the importance of rockiness and gravel, and Fitch (1938) notes that lack of rockiness seems to be acting as a limiting factor in geographic distribution.

For the Sierra yellow-leg probably the most favorable shoreline of all

is moderately rocky, with many rocks separated several inches or feet by soil supporting grasses, sedges, and low clumps of willows. In such situations the frogs usually crouch in the vegetation between the rocks within one jump of water. Additional shoreline characteristics which lead to an abundance of animals are an irregular ground surface, providing more cover and perches, and a border that undulates several feet to provide pools, a variety of depths, and a longer inhabitable area.

A lack of rockiness rarely leads to an absence of frogs, although their numbers are usually reduced in such areas. In otherwise excellent habitats, except for an absence of rocks, frogs are, naturally, unable to exercise selection for rockiness and are usually to be found along vegetated and irregular margins. In such areas, fallen and half submerged trees are commonly used for shelter and perches.

Most high boreal streams which meander through meadows are sunken one to several feet in the soil and have nearly vertical or commonly even overhanging banks. Streams with banks of less than approximately 10 inches in vertical height harbor the densest populations of frogs, and occasional breaks in the banks, such as those formed by intermittent tributaries, are especially utilized. However, a few animals seem always to occur in unusual habitats, and once near Pine Creek Pass several frogs were seen to leap off banks as high as 3 feet to pools below, which were 2-3 feet deep and without shallow borders. Moreover, the frogs then buried themselves under several inches of a bottom-growing aquatic plant, probably *Selaginella* sp., instead of crouching on the sandy, gravelly, or rocky bottom, or swimming under rocks as is their usual behavior. Near the above location, one adult was even noted to escape capture by crawling 12 inches away from water and entering a rodent burrow to a depth of at least 18 inches. This latter behavior was noted near a very small, semi-stagnant stream. It was the smallest body of water in which frogs were noted, only enough water being present barely to cover a submerged frog. The usual method of escape is to dive into water.

Frogs on banks are extremely wary and difficult to capture by hand, but those resting half submerged on rocks or on the bottoms are easily grasped. The mottled brown colors of the animals blend well with the bottom materials and brown-stained rocks. Reliance seems to be placed upon protective coloration and the overlying water rather than immediate flight.

What Fitch (1938) noted with regard to the concentration of *Rana boylei* to pools as creeks dried up, we also observed with the Sierra yellow-legged frog. On August 28, 1954, low water conditions prevailed in a small creek extending westward from Pine Creek Pass. No water was flowing and only isolated rocky pools remained. Each pool contained an unusually large number of frogs. Pools of 4 and 5 feet across and up to 2 feet in depth held 5 to 10 animals. Presumably the frogs had been more evenly distributed along the previously flowing creek. Abundant water was only about 100 yards away, demonstrating the reluctance of these frogs to cross dry ground. Very few young frogs were found in these pools. Cannibalism may have accounted for their absence, the adults not being adverse to eating at least other anurans such as *Bufo canorus* (Mullally, 1952).

On August 15, 1955, along a stream at Porcupine Flat in Yosemite

National Park at an elevation of 8,100 feet, young *Rana muscosa* were found in the stomachs of 3 out of 4 mountain garter snakes (*Thamnophis e. elegans*) collected.

The absence of yellow-legged frogs from the larger streams of the Canadian and Transition Zones of the Sierras has been attributed to springtime flooding resulting from melting of the snowpack (Storer, 1925: 260). Storer also believed that the condition restricted *Rana boylei* to lower gradient streams in the Lower Transition and lower zones and *Rana muscosa* to lakes and low gradient streams in the Middle Canadian and higher zones. Thus a hiatus of several thousand feet was supposed to exist between the two species. Recently Zweifel (1955: 237-240) has concluded that *Rana muscosa* more frequently selects higher gradient streams than *Rana boylei,* and he has found that the elevational separation between the two species is much less than formerly believed. He suggests that *Rana muscosa* is more common in high-altitude lakes than elsewhere because of the absence of any competing species of *Rana.* We agree with Zweifel that the disparity in elevational ranges of the above two species is less than formerly thought, because unidentified forms of yellow-legged frogs have been noted in Yosemite National Park in the following intermediate localities: Commonly in a lake several miles northwest of Hetch Hetchy Dam at an elevation of about 5,000 feet; commonly in a small, low-gradient stream at Sugar Pine Blister Rust Camp, elevation 5,800 feet; sparingly at an elevation of 6,300 feet on the high-gradient South Fork of the Tuolumne River.

We agree with Storer (1925) that *Rana muscosa* is greatly reduced in numbers in the larger streams of the Canadian Zone, and by the following reasoning we attempt to explain why this is so. Along French and Piute Creeks passing through Hutchinson Meadow, Fresno County, only an occasional young frog and even fewer adults were found despite considerable searching during favorable environmental conditions. This meadow lies at an elevation of 9,500 feet and is zonally Upper Canadian. At higher elevations along these creeks, frogs became increasingly more common, and they were most abundant in lakes and low-gradient streams within meadows. Similarly, in the Upper Canadian Zone of Tuolumne Meadows (8,600 feet) of Yosemite, only an occasional frog was found along the Tuolumne River. However, this drainage harbors many frogs at elevations greater than 9,400 feet. The reason for the small numbers of frogs present in these larger streams is not zonal, because large populations are present at much lower elevations elsewhere. Zweifel's suggestion that *Rana muscosa* is most abundant in high-altitude lakes because of lack of competition with other species of *Rana* seems inadequate to the writers, because, if this is true, then frogs should be abundant in the larger streams at sufficient elevation where other ranas are also absent, and such is not the case. In the summer the habitat conditions of these large streams seem acceptable, if not ideal, with many quiet marginal pools and shallows, and favorable border types. Although parts of the streams have unfavorably high water velocities and depths, the frogs could easily locate in the numerous areas of slower and shallower waters. The large streams in both of the above mentioned areas are formed by the union of many smaller ones which drain from lakes at higher elevations, resulting in floods following the spring thaw. The melting snow probably results in

very cold streams which may hinder the frogs, supposedly dormant in or beside the water (Zweifel, 1955: 242), from effectively swimming and withstanding the torrents. Since the tadpoles overwinter and cannot even avail themselves of the shore, they must be even more susceptible than the adults to the above conditions. The small average size of the animals found at Hutchinson Meadow may reflect the reduced life expectancy along such streams.

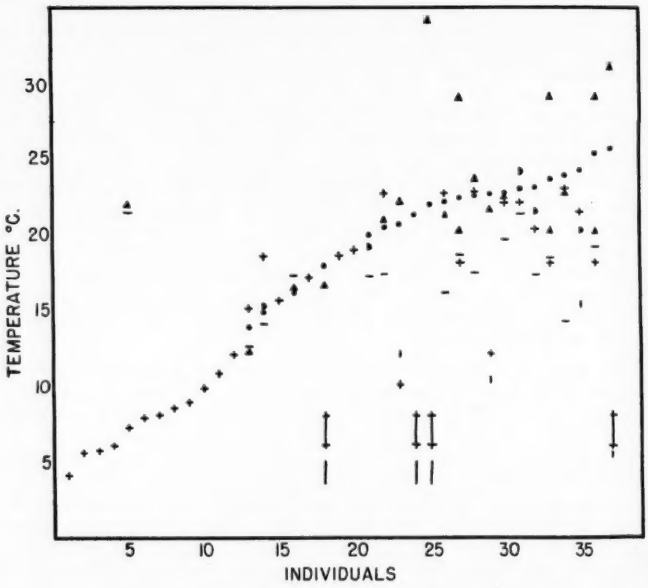

Fig. 1. Body temperatures and thermal environment of *Rana muscosa* in the Sierra Nevada Mountains. The following symbols have been used to designate temperatures: solid circle, body; plus sign, water; horizontal line, air at a height of ½ to 1 inch; triangle, soil surface (two symbols are sometimes used to illustrate range); half circle, rock surface; vertical line, air at a height of 5 feet. See text for a discussion.

TEMPERATURE RELATIONS

Available temperature data are presented in Figure 1. They have been arranged in such fashion that the temperatures of each animal and parts of its environment lie in a vertical series and so are easily compared. Direction is given to the plotted data and other broad comparisons are made possible by arranging the body temperatures in ascending order. Submerged animals quickly assume the temperature of their medium and for that reason water temperatures that prevail beside the frogs are often substituted for body determinations. Elsewhere and with further discussion

we have utilized basically the same scheme of arranging temperature data (Mullally and Cunningham, 1956).

Data were obtained only during the months of August and September and are thus indicative of the summer season. Although most of the data were accumulated under warm conditions, a few unusually cold days resulted in temperatures approximating the weather prevailing during late spring and early fall. Observations made during such times were especially interesting, because the animals must then function under low temperature conditions, adaptation to which is of prime importance to the survival of an alpine animal. Observations included in this paper only cover the daylight hours. Under crepuscular conditions a few animals have been noted along the shore half submerged or, more rarely, a few inches from water. After sunset, activity and numbers of visible animals are reduced, and it is our impression that at least at the higher elevations the species is mainly diurnal. Only rarely are the environmental conditions at night warm enough for terrestrial surface activity.

During August 24 to 27, 1954, unusually cold and windy weather was encountered in the Humphrey Basin. In our camps at elevations of 9,500 to 10,800 feet, nightly air temperatures at ground level descended to -4 to -9° C. resulting in heavy frost, lightly frozen moist soil, and ice along the borders of creeks and lakes, with small, still pools becoming completely frozen over. Nearly all morning was required to melt the ice formed each night, but by at least 8 a.m. frogs were found basking in the sunshine on the banks. The stream near Desolation Lake descending from about 12,000 feet to 11,500 feet elevation held a heavy complement of active tadpoles and frogs. Ice sufficiently thick to support the adult animals extended up to 20 inches from quiet shores to moving water of 6-8° C. When frightened, frogs jumped from the banks into the creek and swam to the bottom, and in a few minutes they returned to the same stretch of bank to resume basking. Frequently the animals lit upon the bordering ice sheet rather than in water, and at such times they slid or hopped to the edge and fell into the water. Since this happened so commonly, it seemed evident that the frogs were not making an effort to avoid the ice, and it also seemed to us, as it did to Grinnell and Storer (1924:665), that the frogs did not visually perceive the difference between ice and water.

Swimming Sierra yellow-legged frogs were noted to pass through waters at least as cold as 2° C. next to ice while warmer waters were only inches away. The coldest water of nearly uniform temperatures noted with active frogs was within a pool of 4° C. Even in the coldest weather, flowing parts of the creeks were 6° to 9° C., or far warmer than the bordering ice indicated. At water temperatures of down to 4° C., apparently frogs of all sizes are fully active and not obviously hindered by the cold from swimming about and climbing onto shore. Meager data on lower temperature relations prohibit final decisions, but even water temperatures of 3° C. do not seem to incapacitate the animals or induce torpidity. Tadpoles have also been observed swimming in water varying between 4.0 and 5.9° C.

Although parts of the creek were very cold early in the morning, the remainder of the frogs' immediate environment quickly heated to higher levels. One morning at 9:30 to 10:00, the air temperature at a height of

5 feet varied from 3.5° to 5.6° C., and on a level slope, dry-surfaced soil covered by sparse low grasses registered up to 34° C., and moist soil up to 16.5° C. Insolation provided the heating. Frogs which had rested for a long time in the sun on these surfaces registered 17.8 to 25.50° C., with the warmest animals occurring on the warmest soil. The temperatures of the animals more closely resembled those of their immediate substrata than of any other part of the recorded environment, confirming the data of Zweifel (1955: 228). The question is not resolved whether high body temperatures were mainly derived from the substratum or from insolation. It is possible that both animal and substratum are heated by direct radiation to somewhat similar temperatures. However, in the absence of direct sunshine, frogs which have long rested upon moist soil thermally approximate it to within 1 - 3° C. When frogs rest in the shade, in shallow water, or on mud a few inches from the water, as they frequently do, the frogs, the mud, and the shallow water are usually at nearly the same temperature. Under midday sunshine, even moist soil and shallow water often heat to a higher degree than the animals tolerate. Dry soil becomes much too warm, surface temperatures of 55-60° C. being common. Inspection of figure 1 and the data of Zweifel (1955: 227, 242) reveals that the general air temperatures are also usually distinctly different from body temperatures.

The description of relations near Desolation Lake is a good example of the effect and importance of the microclimate. While the general air and water temperatures were between 3.5 and 6° C., with ice present, the frogs had body temperatures up to 25.5° C., and the positions they occupied were even warmer. Furthermore, although much work has been done during midday in warm weather, no higher body temperatures have been obtained. Our next highest body temperature, 25.2° C., was secured under another set of poor heating conditions - late in the afternoon in feeble sunshine. No doubt equivalent or even slightly greater heating is attained in warm weather, but it is probable that in the proximity of much heat, body temperatures quickly proceed to intolerable levels, forcing the animals to retire to cooler sites. Examination of Zweifel's temperature data (1955: 227, 242) for *Rana muscosa* and the apparently similarly thermally adapted *Rana boylei* reveals that he also failed to find body temperatures of over 25.6° C. Thus the available data seem to indicate closely the maximum voluntary body temperature.

Since higher body temperatures lead to greater abilities in escaping enemies and probably accelerate growth and maturation during the short warm season, it seems strange that the Sierra yellow-legged frog does not regularly tolerate higher body temperatures. Certainly they are able to survive much higher thermal levels. Animals brought to Los Angeles were subjected to preliminary experiments in an effort to determine their maximum lethal temperatures. After several days of acclimation to room temperature (23° C.), all 7 survived 3 hours exposure to 32-33° C. in a chamber of 100 per cent relative humidity. A temperature of 37° C. was quickly fatal to all individuals. Apparently the low maximum tolerance of the adults is correlated with the thermal physiology of the embryos and larvae. The embryos of *Rana boylei* and probably *Rana muscosa* develop normally only in water of up to slightly less than 26° C. (Zweifel, 1955: 262). We have not found tadpoles in water warmer than 27.0° C., al-

though warmer waters have been available and are inhabited by larvae of *Bufo canorus* and *Hyla regilla*.

While in cold, sunny weather, frogs maintained body temperatures ranging from very low to very high. During warm weather the average body temperatures are much higher, however. At midday, most frogs and the waters they frequent have temperatures of 15 to 22° C. Under good heating conditions, marginal waters an inch or less in depth may heat to over 34° C., and the frogs often briefly pass through these waters. As is the case for other amphibians (Bogert, 1952: 128-129; Cunningham and Mullally, 1956; Mullally and Cunningham, 1956), the Sierra yellow-leg does not maintain a narrow range of body temperature by its behavioral mechanisms as do many reptiles (Cowles and Bogert, 1944). Body temperature control in these frogs merely involves moving to a cooler location when overheated, apparently in excess of 25.6° C., or basking when many degrees cooler. While exposed to a particular thermal environment, large numbers of frogs are found to possess rather similar body temperatures, but this similarity is fortuitous and should not be construed to be the result of preference. A large range of body temperature, at least between 15° and 25.6° C., induces no evident effort toward thermal relocation, and a range from at least 4° to 25.6° C. is favorable to casually observable activities. These tolerances are probably to be expected from an animal that continually undergoes the transition from high terrestrially-gained body temperatures to cold water without a period of acclimation.

SUMMARY

1. Near Desolation Lake in Fresno County, Sierra yellow-legged frogs were found up to an elevation of over 12,000 feet, and tadpoles up to 11,600 feet.

2. An analysis is made of distribution along bodies of water at high elevations. The frogs are highly aquatic and are most common along lakes and low-gradient streams, especially those with irregular shores and plentiful rocks.

3. At Porcupine Flat in Yosemite, young *Rana muscosa* were found to be an item of food for *Thamnophis e. elegans*.

4. Frogs were found active early in the morning after subfreezing nights despite the presence of ice in the streams. They swam in water as cold as at least 4° C. Frogs basking on the banks warmed to 25.5° C. Most heating seems to come from the substrate, and general air temperatures. The frogs do not maintain a narrow range of body temperature by behavioral mechanisms as do many reptiles.

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The Taxonomic Relations of the Water Snakes *Natrix taxispilota* and *rhombifera*

By J. William Cliburn

Superficial examination of the snakes *Natrix taxispilota* (Holbrook) and *Natrix rhombifera* (Hallowell) reveals obvious similarities which suggest a closer relationship between the two than is usually acknowledged. An investigation still in progress has revealed evidence of intergradation of these two forms. As suggested by me (Distribution and variation of water snakes of the genus *Natrix* in the state of Mississippi and adjacent Louisiana and Alabama, Unpublished Master's Thesis, Miss. Southern Coll., 1953: 1-82), they are of one species. Cagle (1952), without discussion, lists them as *Natrix taxispilota taxispilota* and *N. t. rhombifera*. Neill (1954, Publ. Res. Div. Ross Allen's Rept. Inst., 1:85) agrees to this arrangement, but again without citing evidence. Consequently, I believe a report of my investigation, incomplete as it is, is merited.

A detailed examination was made of 46 specimens of *Natrix rhombifera rhombifera* from the following locations: *Mississippi*—Indianola (1), Sunflower Co.; Big Black River (2), Madison Co.; near Pearl River (4), Rankin Co.; near Magnolia (1), Pike Co.; west of Hattiesburg (6), Lamar Co.; Carnes (1), Brooklyn (5), and vicinity of Hattiesburg (9), Forrest Co.; Richton (2) and Beaumont (1), Perry Co.; Saucier (2), Harrison Co.; northwest Jackson Co. (1); north of Waynesboro (1), Wayne Co.; locality unknown (1). These specimens are in the Department of Zoology Museum, Mississippi Southern College. Other examples from the Department of Zoology Museum, University of Alabama, which were studied in detail, are as follows: Waggaman (4), Jefferson Par., La.; Marion (4), Perry Co., Ala.; Tuscaloosa Co.

(1), Ala. Additional specimens studied for variations in dorsal pattern are from Hancock, Greene, Amite, and Bolivar Counties, Mississippi, and from Mobile County, Alabama.

Scale data for these snakes are as follows: subcaudals 61-80, with an average of 69; ventrals 130-146, averaging 134.6; ratio of subcaudals/ventrals .423-.583, averaging .505; scale rows 27 in 24 specimens, 29 in 15, 25 in 5, and 23 in one specimen; supralabials 8-8 in 44 specimens, 7-8 in one specimen, and 10-10 in one specimen; infralabials 11-11 in 28 specimens, 12-12 in 7, 12-11 in 5, 11-10 in 3, and 11-12, 10-10, and 10-11 in one specimen each; postoculars 3-3 in 42 specimens, and 2-3, 3-4, 4-3, and 4-4 in one specimen each; preoculars 1-1 in 44 specimens and 2-2 in 2; anterior temporals 1-1 in 40, and 2-2 in 6 specimens; posterior temporals 3-3 in 17 specimens, 2-2 in 16, 3-2 in 6, 2-3 in 6, and 4-3 in one specimen; ratio of tail length/total length .208-.288, with an average of .244.

Extensive collecting in southeastern Mississippi and coastal Alabama has not produced specimens of *Natrix taxispilota*. However, it probably occurs, since Cagle (*op. cit.*) credits it to Louisiana, and Chermock (1952, Geol. Surv. Ala. Mus. Pap., 33: 1-88) reports it from Alabama. A specimen in the Mississippi Game and Fish Commission Museum from Adams County, Mississippi, was examined personally, and Boyles (Variation and distribution of water snakes of the genus *Natrix* in the state of Alabama, Unpublished Master's Thesis, Univ. Ala., 1952: 1-70) records a specimen from Baldwin County, Alabama. Apparently this snake has an extremely narrow range of distribution in this area, where it probably replaces *rhombifera*. Its occurrence in the Mississippi River drainage as far north as the vicinity of Natchez tends to indicate that its widest distribution in Mississippi occurs within that drainage system.

Two specimens of *N. taxispilota* were examined from Lake County, Florida. Scale data are as follow: subcaudals 67 in one specimen; ventrals 132, 133; ratio of subcaudals/ventrals .508 in one specimen; scale rows 31, 29; supralabials 8-8; infralabials 12-11 and 12-12; postoculars 3-3; preoculars 1-1; anterior temporals 2-2 and 3-3; posterior temporals 4-4 and 0-0; ratio of tail length/total length .242 in one specimen. Data for the Adams County, Mississippi, specimen are included below for purposes of comparison, since *taxispilota* probably occurs in coastal Mississippi: subcaudals more than 62; ventrals 133; scale rows 31; supralabials 8-8; infralabials 12-12; postoculars 2-3; preoculars 1-1; anterior temporals 3-2; posterior temporals 4-4.

There are at hand two bodies of evidence indicating a blend of *rhomifera* and *taxispilota*. Typically, *taxispilota* differs from *rhombifera* in having a greater number of dorsal scale rows, numbering 27-33, while *rhombifera* is described as having a range of 25-33 scale rows. Examination of specimens from north central Alabama (Tuscaloosa, Perry, and Greene Counties) reveals that the usual number of scale rows encountered in *rhombifera* in that part of its range is 25. Specimens from south Mississippi (Forrest, Lamar, Perry, Wayne, Pike, and Madison Counties) reveal typically a higher scale row count, as do specimens from Jefferson Parish, Louisiana. According to Boyles (*op. cit.*), 60% of the northern group examined by him have 25 rows, while 23% have 27 rows. Of the southern group examined by the present author, only 11% have 25 scale rows,

while 49% have 27, and 33% have 29 rows. This may be interpreted as a trend toward the higher average scale count of *taxispilota.*

In dorsal pattern also, indications of intergradation are noted. The pattern of *rhombifera* consists of dorsal blotches alternating with lateral bands, to which they are usually joined by a narrow stripe. Dorsal blotches cover 5-6 scale rows across the back, and are from 2-3 scales in width. In *taxispilota,* the dorsal blotches are not joined with the alternating bars, and blotches and bars are wider, so that in appearance the markings are more nearly equilateral than in *rhombifera.*

Specimens of *rhombifera* from southern Mississippi (Rankin, Lamar, Jackson, Hancock, and Perry Counties) are at hand which closely approach the typical dorsal pattern of *taxispilota,* and are considered by the author to represent a blend of the two species. In these examples, the dorsal blotches and lateral bars are either imperfectly joined or else are not joined at all. Patterns also vary in the number of dorsal body blotches, which in *taxispilota* is typically 21-25 (Schmidt and Davis, Field Book of Snakes, 1941). For *rhombifera,* the number is 26-33 (Cagle, *op. cit.*). Of the group of *rhombifera* having dorsal patterns reminiscent of *taxispilota,* it has been found that those specimens most closely resembling *taxispilota* also usually reveal a number of dorsal blotches which falls within the range given for *taxispilota.* Of the examples whose patterns do not resemble *taxispilota,* none have a number of blotches which falls within the low range of *taxispilota.*

Apparently, pattern and number of scale rows are more variable characteristics than is the number of anterior temporals. A divided anterior temporal is occasionally encountered in *rhombifera,* but no normal upper and lower anterior temporals were observed in any of the specimens. (One specimen, 53-964 MSC, from Sunflower County, Mississippi, has two anterior temporals on each side. On the left, one scale is located above the other, as in *taxispilota.* Since other head scales are very irregular, this arrangement of the temporals is of doubtful significance. In this snake, there are 4 small scales between the frontal and the parietals. Each parietal is further subdivided into 3 smaller scales. However, *taxispilota* occurs in the Mississippi Valley as far north as Natchez, and if these two forms are races of the same species, intergradation may well be expected in this region.)

The evidence at hand indicates the trend of typical *rhombifera* to grade into *taxispilota.* Intergradation occurs first in number of scale rows on a north-south gradient. Dorsal color pattern of *rhombifera* grades into *taxispilota* in Mississippi essentially from Forrest County south and west, with those specimens from Hancock County showing the characteristic most markedly in the tail region. The key character (that is, anterior temporals) shows no intergradation except possibly in one Delta specimen.

On the basis of evidence revealed by the study, the author endorses the taxonomic arrangement suggested by Cagle and Neill, to wit, that these two serpents should be referred to as *Natrix taxispilota taxispilota* and *Natrix taxispilota rhombifera.*

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Further Observations on Spadefoot Toads

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In a series of papers (Bragg, 1944 to 1956) I have reported observations on the breeding activities of spadefoot toads in Oklahoma and, along with these observations, several notes on the types of pools utilized; developmental and growth rates of their tadpoles; and behavior, feeding and metamorphic aggregations of the larvae with some emphasis on their food supply. The purpose of the present paper is to give some further evidence of metamorphic aggregations as observed in the spring of 1955 and to discuss especially, in more detail, the nutritional changes in individual pools previously mentioned more briefly (Bragg, 1950). The present work is based wholly on the savannah spadefoot, *Scaphiopus holbrooki hurteri* Strecker, and this subspecies is to be understood wherever the term spadefoot is used.

Oklahoma has been under drought conditions for the past two years and the spadefoots have not utilized all pools available to them. Because of continued lack of rain in suitable amounts, spadefoot breeding was late this year (1955) in the pools commonly studied. Two pools (A and C) had no breeding activity in them. One pool (I) hatched most of two clutches of eggs but the tadpoles inexplicably disappeared completely from this site after feeding for about three days. Two other pools produced tadpoles of spadefoots for the first time in ten years of observation. In one of these the behavior was usual for the species. In the other, the water evaporated too quickly, killing all the larvae just as they were beginning to form feeding schools. The observations, therefore, were principally made at sites earlier designated as pools D, E, and F, located close together approximately 16 miles east of Norman, Cleveland County, Oklahoma, beside Oklahoma Highway 9 (pool D) and in a pasture a few rods to the northeast (pools E and F).

During and after heavy rain, the spadefoots produced one clutch of eggs on the night of May 9, two on May 10, and three on May 11 in pool D. No eggs were laid on May 9 at pool E; but on the 10th and 11th, so many were produced that I could not determine the number of adult pairs involved. In pool F at least three clutches were laid on May 11 but none on the other nights. In each case I saw the breeding congresses during the night and found the eggs in the pools the next day. Thereafter, I visited the pools at least once each day (often more) to observe the condition of the pools and the growth rates of the animals, until all had metamorphosed.

Various embryonic stages were noted, depending upon the age of the animals; and by the late afternoon or early evening of the 13th all had hatched and the older ones were scattered, swimming in all parts of the

Contribution from the Department of Zoology and the Oklahoma Biological Survey, University of Oklahoma, Norman.

pool. In general, each clutch hatched about 48 hours or less from egg laying (the exact time of egg production is unknown, but in each case it was between about 11:00 p.m. and daylight the following morning). Thus, the rate of embryonic development was approximately the same in all clutches in all these pools. Eggs laid in pool I also developed at about this same rate.

The tadpoles in pool D on the 14th seemed at least twice the size that they had attained only about 24 hours before, indicating an enormous growth rate. They were feeding voraciously in the shallows, nibbling in groups at plant stems, or aggregating in feeding schools and eating the bottom materials. This is the youngest stage at which I have ever seen feeding schools; and, at this time, at least, it was *not* due to involuntary crowding—the pool was well filled with water. The water temperature was 32° C. at this time (2:30 p.m.). The next afternoon they had again markedly increased in size, being now fully half the bulk of many seen at metamorphosis at other times. Their essential behavior had not changed. Water temperature was 24° C. at 2:00 p.m. Heavy rain on the night of the 18th and most of the 19th filled and roiled the pool. No tadpoles could be seen at the surface nor in the shallows during the rain. Hind-limb buds were appearing on the 20th and the changing coloration on the dorsal parts of the animals indicated that metamorphosis was beginning. On the 25th, completion of metamorphosis was imminent. A sample from one feeding aggregation showed none with forelegs although they were obviously about to break through.

Heavy showers that night again replenished the pool. At about 1:30 p.m. the next day (May 26) a single metamorphic aggregation near one bank was all that could be found. The tadpoles were aggregated but *not feeding*. Evidently, about half of the tadpoles here had emerged and scattered during the night. That evening at 8:30, large numbers had emerged from the metamorphic aggregation seen in the afternoon, and others were swarming to the bank from this aggregation. Within a few minutes, all except a few stragglers had come out. None was found in or about the pool on the 28th, less than 48 hours later. This is the third time that spadefoot tadpoles have been seen to seek the bank through a mass movement from a metamorphic aggregation (Bragg, 1951, 1955).

Presumably tadpoles from eggs laid on the night of the 9th emerged to the bank on the night of the 25th, taking just less than 16 days from egg laying: those from eggs laid the night of the 11th emerged about 24 hours later, therefore using the same total time (within a few hours) as the others for full development. When did individuals from the eggs laid on the 10th metamorphose? Since there were only two nights of emergence, three possibilities are evident: they metamorphosed (1) with the first group (or slightly later the same night), (2) with the second group or (3) some emerged with the first and the remainder with the second group. In any case, none in the pool took longer than 16 days and some may have required only 15 from egg to metamorphosis.

I have presented the observations at pool D in some detail in order to compare with pools E and F where the sequence of events was significantly different. In these two pools, developmental rates to first feeding were the same as in pool D and behavior during the first three days was similar. Feeding aggregations were common in both but slightly more

prevalent in F than in E. However, in neither pool did the tadpoles grow nearly so fast as in D. Water temperatures whenever taken (each day, most often in the afternoon) were comparable in all three pools and were often the same, usually varying no more than 1° or 2° C. When there was a difference, higher temperatures were correlated with the shallower pools F and E, in which tadpoles were much smaller than in D. It seems clear, therefore, that temperature differences were not responsible for the differential growth rates observed. Temperatures varied between 25° and 34° C. (usually about 32°), both lower and higher than previously observed at various times in pools where the tadpoles maintained a much faster growth rate. It seemed obvious that the nutritional conditions in pool D were very good as contrasted with pools E and F, in both of which they were poor. (In several other years, they have been best in pool F.)

Pool F lost water rapidly through evaporation and pool E lost it even faster through both evaporation and seepage. On May 16, pool F had only a little water and pool E had been separated into two shallow pools in each of which tadpoles were in dense, nonsocial, feeding aggregations. They were no more than two-thirds the size of the animals in pool D and about comparable with those in F. The next afternoon (May 17) all tadpoles in one of these subpools at E had died as the water disappeared completely (except for slight moisture) and those in the other subpool were struggling in about 1½ inches of water; but they were schooling in two definite feeding aggregations with a stream of water passing out behind each school carrying bottom debris with it. In F there was even less water; all tadpoles were in a single voraciously feeding school, densely packed. A collection was made from the school in E and another from F added to it. Schooling continued in the jar used for the collection.

I fully expected that all tadpoles in both E and F would die from lack of water before my next visit, but heavy showers fell during the evening, completely refilling both pools. On the next afternoon I found that the rain had been in time to save those in F but not in E. In the latter, thousands of dead tadpoles in perfect condition were floating on the surface of the newly filled pool. Only two live ones were found in this clear pool where observational conditions were excellent. If the rain had come less than an hour sooner all tadpoles here probably would have lived.

Recalling laboratory experiments (Bragg, 1950) in which it was found that both growth and developmental rates in *S. h. hurteri* are stimulated by dead tadpoles utilized as food, I saw an opportunity here for a field experiment. Accordingly, I collected many hundreds of these dead tadpoles from the surface of pool E and put them into pool F where nutritional conditions had just been found to be poor (and thus would serve as good control) to determine if the developmental or growth rate of the tadpoles there would increase.

An increase in the growth rate was expected but the result was truly remarkable. Within 24 hours the tadpoles here were at least half again as large as when the dead tadpoles were added and they continued to grow at a rate much faster than the larger tadpoles in D. They approached

metamorphosis at the same time as those in D and were emerging from a dense metamorphic aggregation at the same time that those in pool D were coming to the bank on May 26. Their sizes were slightly less than those in D, showing that their growth rate during the last half of their aquatic phase greatly exceeded that of the larvae in pool D. Incidentally, this is the fourth case of observed mass movement to the bank from a metamorphic aggregation.

The results of these observations clearly confirm previous conclusions concerning the nutritional conditions in different pools at the same times and in the same pool sites at different times (Bragg, 1950). Under the drought conditions of the past few years, pools E and F have lost nutritional value for these tadpoles. Pool D has not changed noticeably. Also confirmed is the conclusion (Bragg, 1954) that dead tadpoles are a very important factor in survival of spadefoot tadpoles by stimulating growth and development rates as the water level falls dangerously low. It is still not clear, however, whether this works through increasing and bettering the general nutrition of these animals or through some special substance concentrated in the bodies of dead tadpoles and needed for transformation as suggested as a possibility earlier (Bragg, 1950). Laboratory experiments are needed to determine this point.

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The Seasonal Behavior of Certain Floridian Salientia

By GERALD E. EINEM and LEWIS D. OBER

The mild climate of the Florida Peninsula affords Salientia a prolonged activity period reflected by, among other traits, their extended breeding and shortened "hibernating" cycles. While photographing frogs in chorus and in amplexus, data were gathered which extend previously recorded limits for the breeding season of various species. The data of novel import are presented herewith.

In this paper a chorus is defined as a group of ten or more male frogs emitting their normal breeding calls from standard breeding situations. Although ovulation and fertilization are more conclusive breeding criteria, the calling of males is believed to be indicative of potential breeding as related to the speramatogenic cycle.

Various authors indicate that male frogs, outside of their breeding period, emit calls nearly identical (perhaps weaker and shorter) with normal breeding calls. For example, Noble (1931: 409) wrote, "Some pond frogs call after the breeding season has passed. These cries, like the summer songs of birds, may not be an expression of sex desire, but with the limited repertoire at the frog's disposal, they may be precisely like the sex call." Much of this calling, which might seem to be outside of the breeding season, can be regarded as confined to the period of potential sexual activity in males (when they possess mature spermatozoa). For instance, certain northern frogs which usually breed only in the spring or early summer often call again in late summer or fall, singly or in choruses, from terrestrial or aquatic situations. Such late calling has been reported for the northern *Hyla crucifer* by Dickerson (1906: 147) as well as for *Acris gryllus crepitans* and *Rana p. pipiens* by Pope (1944: 84, 138). Blair (1951: 178) reported hearing *Pseudacris nigrita triseriata* calling on November 23 in Oklahoma. Late and early sex call dates often later prove to be coincident with oviposition. For example, Blair's *P. n. triseriata* might have bred during warmer weather, for Livezey (1952: 372) found evidence of breeding in Texas on November 18-21. This was also demonstrated for *pipiens* by Wright and Wright (1949: 495), who observed ten complements of meadow frog eggs on September 12, 1929, as far north as Olney, Indiana. That this fall breeding could potentially continue through the winter even in northern *pipiens* was proven by Rugh (1951: 39-40) as follows: "Spermatozoa may remain thus [with heads in Sertoli cells] throughout the entire period of hibernation only to be liberated under the influence of sex-stimulating hormones during the early spring. These spermatozoa are functionally mature as can be demonstrated by dissecting them from the testes and using them to fertilize frog's eggs artificially at any time from late in August until the normal breeding season in April or May." The male's thumb pad and probably his sex cell are developed during these same months, but the proper combination of warm weather and humidity are necessary before the sex cell is heard.

The popular use of male *Rana pipiens* for pregnancy tests at any time of the year, through simply exposing them to sex hormones that in turn release sperm, is ample evidence that at least in this species the sexual

potential is virtually continuous. Release of the potential is normally dependent upon coincidence of proper temperature and rainfall, primarily external factors. These effect the limitation of actual sexual activity to given seasons.

In this paper the section on *Pseudacris nigrita verrucosa* best illustrates how Florida's winter weather effects what is believed to be a nearly similar sexual cycle and how the sporadic terrestrial calling of frogs during one winter proved to be coincident with choruses during the following warmer and more rainy winter.

In the following accounts all observations for 1952, 1953 and 1954 were made in the vicinity of Melbourne, Brevard County, Florida; a few observations for 1955 came from the Lakeland, Polk County, area. All rainfall measurements were obtained from the United States Weather Bureau stations at Melbourne and Lakeland. All of the rains commented upon were widespread and general.

It should be pointed out that the authors lived right in the breeding ground area, thus making possible continuous observations.

HURRICANE OBSERVATIONS

Of special interest was the effect of the hurricane "Hazel" on the formation of choruses in the study area. Many species of Salientia culminated and concluded their chorusing on October 9, 1953, the day on which the center of the hurricane passed just south of Melbourne between the hours of 3:30 and 5:00 p.m. The air temperature during the rain was found to be 23°C. The rain amounted to 3.56 inches; the wind had gusts of 64 miles per hour.

Previous heavy rains failed to conclude chorusing; for example, even the 1.02 inches of rain that preceded the hurricane on October 4 failed to conclude calling for any species. *Scaphiopus h. holbrooki* was not recorded on this date. However, October 9 was the concluding calling date for the following frogs: *S. h. holbrooki, Bufo t. terrestris, Bufo quercicus, Hyla c. cinerea. Hyla squirella,* and *Microhyla c. carolinensis. Hyla femoralis* and *Rana capito* concluded calling on the evening following the hurricane (October 10), but they did not call on October 9. The day following the hurricane was without rain.

The first heavy rain to follow the hurricane amounted to 2.05 inches and fell in the early evening of October 18 when the air temperature was 21.3°C. Only the usual winter chorusers—*Rana p. sphenocephala, Acris g. dorsalis, Hyla ocularis,* and *Pseudacris n. verrucosa*—were heard on and after this date.

Low temperatures might have caused the cessation of chorusing, but adults of at least some species were still actively feeding long after October 9; for example, adult *H. squirella* were seen actively feeding on insects at windows on the following dates: October 27, when the air temperature was 21.8°C.; November 1, air temperature 21.1°C.; and November 9, air temperature 19.8°C.

ACCOUNTS OF SPECIES

Scaphiopus holbrooki holbrooki (Harlan). Carr (1940: 53) claims that this species breeds from the summer months until middle October. Although he records taking over a hundred on the night of January 12,

1932, he makes no mention of their calling or breeding at that time. Wright (1932: 76) remarks on spring appearance and breeding records from March, after the first heavy rains, until mid-August, with autumn disappearance about mid-October. In a letter dated February 24, 1955, K. L. Hansen, a graduate student at the University of Florida, informed us of two February records for spadefoot breeding, both in Florida. One he recorded himself—February 7, 1955. We recorded a heavy turnout of spadefoots and the formation of a chorus on January 16, 1955, along the Polk City highway north of Lakeland, Florida. All of these records, however, were superseded by Brandt's (1953: 141) observations of calling, amplexus and egg-laying on January 6, 7, and 8, 1953, in Beckley County, Georgia. We recorded late calling and amplexus on October 9, 1953, just after a hurricane.

Even if not the earliest record of spadefoot breeding, our January 16, 1955, observation is still unusual. Emergence from hibernation and commencement of breeding by the spadefoot is usually associated with heavy rainfall. Brandt's January 6 record and our fall records all occurred following heavy rain. Wright (1932: 32) sets no definite amount, but says "heavy rains." Our observation began about 8:00 p.m. as we proceded north on the Polk City Road the evening of January 16. It had started to drizzle about an hour before, and there was no expectation of seeing or hearing any frogs. Suddenly the road was covered with spadefoots. Several were collected. We passed through this area again about 10:00 p.m., and males were beginning to call. Several more were collected. A check the following day with the local weather station revealed that there had been 0.12 inches of rainfall by 8:00 p.m. when spadefoots were emerging and 0.25 inches by 10:00 p.m. when they were already calling. Of those collected seven were males, one was a female, and two were immature.

Bufo terrestris terrestris (Bonnaterre). That this species breeds from March 1 or earlier to September is recorded by Wright and Wright (1949: 202). Carr (1940: 55) says that the season extends from March to September 5. We recorded this toad calling from choruses on September 18 and October 4 and 9, 1953.

On the evening of May 8, 1955, these toads initiated a chorus without a trace of rain having fallen. A thunder and lightning storm threatened and then precipitated a few drops of rain at 8:15 p.m., when the chorus was already well developed along the edge of permanent water in a marl pit. No rain had fallen for two days prior to May 8.

Apparently this toad can be active throughout the winter. One captured and tagged on December 3, 1952, measured 33 mm. in length. Since it had formed the habit of stationing itself beneath the door light of the senior author's home, it was easily recaptured at will. Recapture dates and measurements are as follows: Dec. 3, 1952, 33.0 mm.; Jan. 7, 1953, 38.0 mm.; Feb. 12, 1953, 40.5 mm.; Feb. 21, 1953, 41.2 mm.; Mar. 2, 1953, 43.5 mm; Mar. 22, 1953, 45.2 mm. Average growth during this period was 0.11 mm. per day, 3.3 mm. per month.

Bufo quercicus (Holbrook). Carr (1940: 54) says that this species breeds from April 1 to September 5. In this area the oak toad called

from large choruses as late as October 19 and 25, 1952. During 1953 this toad was recorded from choruses on September 16, 18, and 27 and on October 3, 4, 5 and 9.

Five immature specimens were found to be active in a dried pond area on February 21, 1953. Their average length was 12.3 mm. Adult toads were not found to be active during this winter, but numerous young were seen in damp ditches and drying ponds.

Acris gryllus dorsalis (Harlan). Carr (1940: 55 states that this frog breeds every month of the year, but Wright and Wright (1949: 219) give the breeding dates from February until October. Our data corroborates Carr's statement. Choruses were heard on the following dates: October 18, 1953; December 5, 1953; February 19, 1955. On this last date a din created by this species, accompanied by *Rana pipiens sphenocephala,* was heard in the marginal marshes of the St. John's River.

Pseudacris nigrita verrucosa (Cope). According to Carr (1940: 56) this frog breeds from February to August 15, but Brady and Harper (1935: 109) recorded a chorus on January 20, 1932, at Royal Palm Hammock, Dade County, a fact indicating a longer breeding season.

Breeding choruses of this frog are usually associated with temporary water and dense herbaceous vegetation; and, in the winter, its calls are heard in conjunction with those of *Hyla ocularis. P. nigrita* are difficult to find, for they vocalize from the densest available cover (partially submerged sedge and grass tussocks) even when places with deeper and/or open water but less cover are convenient.

During the fall of 1952 this species was heard calling in chorus and sometimes observed amplexing on the following dates: September 27; October 17, 19, 25, and 26; November 19.

During the following December and January these frogs sounded their regular breeding calls from permanently terrestrial situations; no temporary water was available. Such scattered individual calling came from the dense cover of wiregrass (*Aristida spp.*) and low gallberry shrubs (*Ilex glabra*). One to four individuals were heard on each of the dates of Dec. 2, 7, and 18, and Jan. 7 and 9. When calling (between 4:30 p.m. and 6:30 p.m.) the air temperature was between 13° C and 20° C.

Early spring breeding ensued with the arrival of warm rains during the evenings of February 2 and 3, 1953. On February 2 at 7:30 p.m., when the water and air temperature were exactly 15.5°C, *nigrita* called in chorus. Their bodies were half submerged in the water and nearly in a vertical position.

No records were kept during the summer of 1953. In the fall of 1953, *nigrita* called in chorus from inundated areas on the following dates: September 16, 18, 27; October 3, 4, 8, 9, 18, 19; November 24, 25 (air temperature 12°C, water temperature 18°C) and December 2, 5, 23, 24. More recently, choruses were heard on December 27, 1954. Thus breeding activities can be expected during some winters but not during others.

Evidently cold or dry weather inhibits breeding; and warm, wet weather induces breeding to continue through the winter. The calling of

these frogs from situations other than breeding ponds seems to indicate that they were potential breeders, for they formed regular breeding congresses the following year when environmental conditions were proper.

There are few precise records concerning the habitat of this frog other than those describing its breeding sites. On the overcast afternoon of November 7, 1953, a mature *nigrita* was discovered in what appeared to be an old armadillo foraging hole three inches deep and partly concealed by dead grass. The locality was in a dry flatwoods adjacent to a small hammock. No *nigrita* were ever found under fallen cabbage palm fronds or other litter under which *Eleutherodactylus ricordi planirostris* (Cope) were so common.

Hyla ocularis (Bosc and Daudin). Carr (1940: 57) said, "They [*Hyla ocularis*] breed during every month of the year . . .," but more recently Wright and Wright (1949: 268) stated that this frog breeds from January to September. Our data helps to substantiate Carr's statement, for we have recorded large and small choruses of these frogs on September 16, 18 and 27; October 4, 8, 9, and 18; November 24 and 25; and December 5 and 24, 1953.

Wright (1932: 32) found that *ocularis* spawned in the Okefinokee Swamp at minimum temperatures between 21°-26°C. On the November 24 date recorded above, the air was 20°C at 9:20 p.m. On the November 25 date the air was 12°C and the water was 18.5°C at 8:00 p.m.

During cold weather choruses of *ocularis* are always much weaker than those of *P. n. verrucosa.*

Hyla cinerea cinerea (Schneider). Carr (1940: 59) stated that this species commences breeding on March 8 and continues until the middle of August. Moulton (1954: 171) recently recorded a chorus and ovulation as late as August 25 at Bradenton, Florida. In the Melbourne area choruses were heard as late as September 18 and October 9, 1953.

Wright (1932: 32) declared that this species required at least 0.84 inches of rainfall for spawning to be initiated. Evidence is accumulating which indicates that *cinerea* will call, amplex, and probably ovulate without necessarily being stimulated by rainfall. At Melbourne on May 9 and 14, 1955, *cinerea* called in chorus after less than 0.01 inches of rain. Near Lakeland, Polk County, Florida, *cinerea* were seen in amplexus in an artificial fish pond on March 18, 1955, when the only rain during the preceding month had been 0.01 inches six days before.

Under the favorable environmental conditions found here in Florida *cinerea* is active at least sporadically the year-round. On every visit to the artificial fish ponds mentioned above they were encountered. They were observed active on the following evenings: October 3, 1954; January 12 and February 5, 1955. In addition, numerous observations were made at other sites, but no definite records were kept. The junior author, accompanied by two other biologists, spent every Saturday morning between January 29 and April 2, 1955, searching for salamanders along the borders of Lake Deeson and Lake Parker and Saddle Creek, all near Lakeland, Florida. At Saddle Creek, particularly, *cinerea* were almost always observed among the hyacinths and pickerel weeds (*Pontederia* spp.).

Hyla squirella (Sonnini and Latreille). Carr (1940: 61) stated under breeding, "I have records from April 2 to August 20." Wright (1932: 316) said, 'Our last record of calling came September 15, 1922." At Melbourne we recorded an early spring chorus on March 26, 1955, and late fall choruses on September 16, 18, 27 and October 3, 4, 5, and 9, 1953, as well as October 19 and 26, 1952.

Wright (1932: 32) states that 1.42 inches of rain are necesary to initiate spawning in this species. During the spring of 1955, individual *squirella* were first heard calling from terrestrial situations on March 1 (3:30 p.m.), March 12 (4:15 p.m.), and March 15 (5:10 p.m.). March rainfall was as follows: March 8, 0.03 inches; March 24, 0.37 inches; March 26, 0.20 inches, a total of 0.60 inches. Not until this last date was a chorus of about 15 *squirella* heard, and then this at an artificial pond formed by irrigation water. These March rains were not sufficient to form temporary ponds. Thus, as in the case of various other species, sufficient surface water often seems to be more important in provoking a chorus than the amount of rainfall.

In most of Florida, where sandy soils do not allow water to remain surfaced for long, ground water conditions are important in determining the effectiveness of a rain as a breeding pond creator. Man's lowering of the ground water table might seriously affect the populations of temporary pond breeders.

Hyla femoralis (Sonnini and Latreille). In Lake County, Florida, *femoralis* breeds from April 2 to August 15 according to Carr (1940: 60). Brandt (1953: 143) reported hearing the calls as early as March 25 in Beckley County, Georgia. Wright (1932: 281), writing of the Okefinokee, recorded: "September 16. Several heard at night during heavy rain." At Melbourne this species called in chorus on September 16, 18, 27; October 3, 4 and 10, 1953.

Some interesting observations were made on the wintering habits of *femoralis* and *H. squirella.* An attempt was made to locate them in their "hibernating" niches on January 14, 1955, after a cold wave had moved into the area. The low air temperature on that morning was 3.5°C. No hylids were found in the open nor under fallen palm fronds or other litter. While one *femoralis* was found under the bark of a dead sand pine (*Pinus clausa*), this species and *squirella* proved to be more abundant in the axils of the large green leaves of the air plant (*Tillandsia* spp.). Both hylids were also found to be common in the more central axils of cabbage palms (*Sabal palmetto*), which seem to afford an environment similar to that of the air plants.

Our observations strengthen those of Neill (1951: 140) pertaining to bromeliads as a habitat niche. The leaf axils of these air plants hold water long after other available water has disappeared and, in addition, harbor a host of arthropods upon which the hylids can feed. Our observations indicate that *femoralis* and *squirella* are active on warm days throughout the winter. On cold days they are deep within leaf axils; but as the temperature increases, they venture farther and farther from their niche. On the night of January 17, 1955, at 12:20 a.m. a *femoralis* was found sitting on the side of a house, five feet above the ground. The air temperature was 15.5°C.

In this same area an unharmed *femoralis* was found in an air plant after a hot woods fire had scorched the epiphyte and the sand pine upon which it was situated.

Microhyla carolinensis carolinensis (Holbrook).—According to Carr (1940:68) this frog breeds from April 1 to September 3. We recorded it as calling from choruses on the following dates in 1953: September 16, 18, 27 and October 4, 5, and 9.

Rana capito (Le Conte).—Carr (1940: 63) states that this frog breeds from March 13 to November 3. According to Wright and Wright (1949: 437), however, this species breeds during every month of the year. Our chorusing dates are as follows: October 19, 1952; September 18, 28 and October 3, 4 and 10, 1953. Since we lived within easy listening distance of the breeding area, we considered the last of these to be concluding dates for each year. Our records appear to strengthen Carr's contention.

The gopher frog proved to be diurnal and actively feeding during the winter of 1953. On February 25 at about noon a gopher frog was disturbed and observed to jump to a position one foot in front of the burrow of a gopher tortoise (*Gopherus polyphemus*). The observer remained motionless. Within a few minutes an adult lizard (*Cnemidophorus sexlineatus*) came into the frog's view. The frog stealthily approached it, but the lizard quickly disappeared into the grass. During the next thirty minutes the gopher frog sat practically motionless. Finally it was frightened into the burrow.

During this time weather conditions had been exceedingly desiccating. The sky was cloudless and the wind brisk. Since an intensive study of the tortoise burrows had been made in this area and all had been found to have the lower end below the ground water table, it was concluded that this dependable water supply allowed these frogs to subject themselves to the wind and direct sun light. In addition, the burrow of the gopher tortoise must permit this ranid continuous activity, for arthropods are always present; and the minimum temperature of the lower end of the burrow never falls below 18°C.

Other species.—Several other species of frogs were observed in the areas under consideration. *Eleutherodactylus ricordi planirostris* Cope *Hyla gratiosa* Le Conte and *Rana pipiens sphenocephala* Cope were observed, but no new information was gathered concerning them. *Rana catesbeiana* Shaw and *R. grylio* Stejneger were frequently observed in the Lakeland areas, and the latter, *R. grylio,* was heard calling in the Melbourne area. No significant information was gathered concerning either of these. Diligent searching failed to uncover any *Pseudaris n. verrucosa* Cope in the Lakeland area. *Pseudacris ornata* Hollbrook was not recorded in either area. Since intensive observations were made in the Melbourne area, no *ornata* are believed to exist there.

CONCLUSION

There is a dearth of and need for much more precise ecological information relative to anurans. Comparative physiological data, such as

spermatogenic and oogenic cycles for the various species of frogs, need to be known so that correlations, if they exist, can be established between "calling" and actual reproductive potential. Obviously, all of the environmental factors which act as stimuli to "calling" and eventual breeding are not clearly understood, or else critical stimuli for one frog or group of frogs do not constitute significant stimuli for others.

Observations here recorded, although incomplete, justify limited speculation. The data gathered on *P. n. verrucosa* appear to imply that the terrestrial calling of scattered males during the year 1952-53 indicated reproductive potential, for the following year chorusing occurred on the same and later dates. Likewise, available surface water seems to be more important to some frogs than rainfall or humidity, whereas with others the latter factors are paramount. Temperature and evaporation play significant roles in the over-all picture of amphibian ecology, yet too little definite knowledge exists concerning limiting influences.

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Catalogue of the Amphibian and Reptile Types in the Natural History Museum of Stanford University Supplement Number 1

By ALAN E. LEVITON AND BENJAMIN H. BANTA

Since the appearance of the *Catalogue of the amphibian and reptile types in the Natural History Museum of Stanford University* (Leviton, Herpetologica, 1953, pp. 121-132), the number of types in the Stanford collection has about doubled.

The present list includes type material of 41 species of reptiles and amphibians, of which all but 7 have been acquired since the end of 1952. The 7 exceptions represent material inadvertently overlooked by the senior author at the time the first *Catalogue* was prepared. As of December 31, 1955, the Stanford collection contained 18,889 catalogued reptiles and 16,219 catalogued amphibians. Of this number 608 specimens are paratypes and 36 are holotypes.

As in the previous paper some of the paratypic material listed may be preceded by a question mark (?). This indicates that the specimens were in the possession of the investigator at the time he was working on his material and were used in the formulation of the description; however, because the investigator neither designated paratypes nor listed the material examined in his original paper, these specimens were not specifically mentioned.

The following abbreviations are used:

AMNH—American Museum of Natural History, New York City.

BYU—Brigham Young University, Provo, Utah.

CAS—California Academy of Sciences, San Francisco, Calif.

CNHM—Chicago Natural History Museum, Chicago, Ill.

MCZ—Museum of Comparative Zoölogy, Harvard University, Cambridge, Mass.

MVZ—Museum of Vertebrate Zoology, University of California, Berkeley, Calif.

SU—Natural History Museum of Stanford University, Stanford, Calif.

Tulane—Tulane University, New Orleans, Louisiana.

UI—University of Illinois, Urbana, Ill.

UMMZ—University of Michigan Museum of Zoology, Ann Arbor, Mich.

USNM—United States National Museum, Washington, D.C.

EHT-HMS—Private collection of Drs. E. H. Taylor and H. M. Smith, University of Kansas, Lawrence, Kansas, and University of Illinois, Urbana, Illinois, respectively.

orig. no.—original number (original number of Museum from which specimen was obtained by gift or exchange).

A—Amphibian (amphibians and reptiles are registered under separate number series in the Stanford collection.)

*First catalogue, vol. 8, Jan. 1953, :121-132.

ORDER APODA
FAMILY CAECILIIDAE

SCOLECOMORPHUS ULUGURUENSIS Barbour and Loveridge, 1928, Mem. Mus. Comp. Zoöl., vol. 50, no. 2, pp. 180-181.

PARATYPES (2): SU A11519-11520 (orig. nos. MCZ, numbers unknown), collected by A. Loveridge, Oct. 19, 1926; same locality as holotype.

(HOLOTYPE: MCZ 12193, male; Nyingwa, Uluguru Mountains, Tanganyika Territory.)

ORDER CAUDATA
FAMILY HYNOBIIDAE

HYNOBIUS BICOLOR Dunn, 1923, Proc. California Acad. Sci., ser. 4, vol. 12, no. 2, p. 28.

PARATYPE (1): ? SU A14825 (orig. no. CAS 26431), collected by V. Kühne, Oct. 5-15, 1910; same locality as holotype.

(HOLOTYPE: CAS 26447, male; Tsuchima, South Island, Japan.)

HYNOBIUS IKISHIMAE Dunn, 1923, Proc. California Acad. Sci., ser. 4, vol. 12, no. 2, p. 28.

PARATYPE (1): ? SU A14824 (orig. no. CAS 26287), collected by V. Kühne, Oct. 1-4, 1910; same locality as holotype.

(HOLOTYPE: CAS 26318, male; Iki-shima Island, Japan.)

HYNOBIUS RETARDATUS Dunn, 1923, Proc. California Acad. Sci., ser. 4, vol. 12, no. 2, p. 27.

PARATYPE (1): ? SU A14826 (orig. no. CAS 25988), collected by V. Kühne, 1910; Sapporo, Ishikari Prov., Hokkaido Island, Japan.

(HOLOTYPE: CAS 35928, male; Noboribetsu, Iburi Prov., Hokkaido Island, Japan.)

HYNOBIUS VANDENBURGHI Dunn, 1923, Proc. California Acad. Sci., ser. 4, vol. 12, no. 2, p. 28.

PARATYPE (1): ? SU A14827 (orig. no. CAS 25950), collected by V. Kühne, 1910; Central Hondo Island, Japan.

(HOLOTYPE: CAS 26714, male; Nara, Yamato Prov., Hondo Island, Japan.)

FAMILY PLETHODONTIDAE

BOLITOGLOSSA XOLOCALCAE Taylor, 1941, Univ. Kansas Sci. Bull., vol. 27, no. 8, pp. 148-150, pls. 7 and 9.

PARATYPES (3): SU A13118-13120 (orig. nos. UI 10091-10093 respectively), collected by Dr. and Mrs. H. M. Smith, April 16, 1940; same locality as holotype.

(HOLOTYPE: USNM 111371; Cerro Ovando, Chiapas, Mexico.)

PLETHODON NEOMEXICANUS Stebbins and Riemer, 1950, Copeia, no. 2, pp. 73-80.

PARATYPES (2): SU A12764-12765 (orig. nos. MVZ 49030 and 49034 respectively), collected by R. C. Stebbins, Aug. 14, 1949; same locality as holotype.

(HOLOTYPE: MVZ 49033, male; 12 miles west and 4 miles south of Los Alamos, Sandoval County, New Mexico.)

FAMILY ASCAPHIDAE

ASCAPHUS TRUEI CALIFORNICUS Mittleman and Myers, 1949, Proc. Biol. Soc. Washington, vol. 62, pp. 63-64.

PARATYPES (10): SU A2190, collected by M. Hanavan, June 25, 1934; French Creek, Siskiyou Co., California. SU A4636-4642, collected by G. S. Myers and W. A. Gosline, Mar. 27, 1939; 8.6 miles north of Weott, Humboldt Co., California. SU A7371-7372, collected by T. P. Maslin and G. S. Myers, Nov. 9, 1941; 0.5 miles north of road to Holmes, on Redwood Highway, Humboldt Co., California. SU A7390-7399, collected by R. and G. S. Myers, July 14, 1941; same locality as SU A7371.

(HOLOTYPE: MVZ 19142, female; near Klamath, Del Norte Co., California.)

FAMILY BUFONIDAE

BUFO HOUSTONENSIS Sanders, 1953, Herpetologica, vol. 9, part 1, pp. 27-45, fig. 1-7.

PARATYPES (2): SU A12768-12769 (orig. nos. Sanders 3022 and 3026 respectively), collected by J. C. Wottring and W. J. Greer, May 18, 1952; same locality as holotype.

(HOLOTYPE: Sanders 3006 [now in the collection of the Univ. of Illinois], female; Fairbanks, Harris Co., Texas.)

BUFO KELLOGGI Taylor, 1936, Univ. Kansas Sci. Bull., vol. 24, no. 20, pp. 510-511, pl. 45, figs 1-3.

PARATYPE (1): SU A11170 (orig. no. EHT 41), collected by E. H. Taylor, July 20-21, 1934; same locality as holotype.

(HOLOTYPE: EHT-HMS 21; 2 miles east of Mazatlan, Sinaloa, Mexico.)

BUFO WOODHOUSEI VELATUS Bragg and Sanders, 1951, Wasmann Jour. Biol., vol. 9, p. 366-376, figs. 1-4.

PARATYPES (2): SU A12770-12771 (orig. nos. Sanders 1859 and 1864 respectively), collected by O. Sanders, March 8, 1951; same locality as holotype.

(HOLOTYPE: Sanders 1891 [now in the collection of the USNM]; Elkhart, Anderson Co., Texas.)

FAMILY LEPTODACTYLIDAE

ELOSIA PERPLICATA Miranda-Ribeiro, 1926, Arch. Mus. Nac. Rio de Janeiro, vol. 27, pp. 33-34, pl. 5, figs. 1 and 1a.

SYNTYPES (3): SU A11762-11764 (orig. nos. Mus. Nac. Rio de Janeiro S404), collected by W. Erhardt, Dec. 1915; Humboldt, Santa Catarina, Brazil.

Additional syntype specimens are in the collections of the Museum Nacional at Rio de Janeiro.

FAMILY RANIDAE

SCHOUTEDENELLA KIVUENSIS de Witte, 1941, Exploration du Parc National Albert, pp. 89-92, text-figs. 27-28, pl. 1, figs. 1-3, pl. 7, figs. 5-6.

PARATYPES (2): SU A13012 (orig. no. Inst. Roy. Sci. Nat. Belgique 20-1537), collected by G. F. de Witte, Dec. 5, 1933; Rutschuru, Kivu, Belgian Congo. SU A13013 (orig. no. Inst. Roy. Sci. Nat. Belgique 21-1541), collected by G. F. de Witte, March 27, 1934; Mokoto, Kalando (lac Ndaraga), Kivu, Belgian Congo.

(SYNTYPES (2): Inst. Royal des Sciences Naturelles de Belgique, numbers unknown, male and female; passe de Sake, N'Zulu (lac Kivu), Kivu, Belgian Congo.)

FAMILY MICROHYLIDAE

HOPLOPHRYNE ULUGURUENSIS Barbour and Loveridge, 1928, Mem. Mus. Comp. Zoöl., vol. 50, no. 2, pp. 254-258, pl. 2, figs. 3-4.

PARATYPE (1): SU A11522 (orig. no. MCZ 13775), collected by A. Loveridge, Oct. 5, 1926; same locality as holotype.

(HOLOTYPE: MCZ 13766, male; Nyange, Uluguru Mountains, Tanganyika Territory.)

NECTODACTYLUS SPINULOSA Miranda-Ribeiro, 1924, Bol. Mus. Nac., no. 4, pp. 256-257.

SYNTYPE (1): SU A11590 (orig. no. Mus. Nac. Rio de Janeiro 405), collected by W. Erhardt, Dec. 1915; Humboldt, Santa Catarina, Brazil.

Additional syntype specimens are in the collections of the Museum Nacional at Rio de Janeiro, Brazil.

ORDER SQUAMATA
SUBORDER SAURIA
FAMILY SCINCIDAE

EMOIA ARNOENSIS Brown and Marshall, 1953, Copeia, no. 4, p. 201, fig. 1.

PARATYPE (1): SU 13487, collected by J. T. Marshall, July 29, 1950; Ijoen Island, Arno Atoll, Marshall Islands.

(HOLOTYPE: USNM 132131, male; Chittakinmatoroen Island, Arno Atoll, Marshall Islands.)

EMOIA BOETTGERI ORIENTALIS Brown and Marshall, 1953, Copeia, no. 4, p. 204.

PARATYPE (1): SU 13488, collected by J. T. Marshall, July 30, 1950; same locality as holotype.

(HOLOTYPE: USNM 132132, male; Ine Island, Arno Atoll, Marshall Islands.)

EMOIA CAERULEOCAUDA REIMSCHISSELI Tanner (V.M.), 1950, The Great Basin Nat., vol. 10, nos. 1-4, pp. 20-22.

PARATYPES (4): SU 11944-11947 (orig. nos. BYU 7334, 7424, 7508, 7697 respectively), collected by E. Reimschissel, Oct. 1944-Feb. 1945; same locality as holotype.

(HOLOTYPE: BYU 7416; Morotai Island, Dutch New Guinea.)

EMOIA MACULATA Brown, 1954, Fieldiana: Zoology, vol. 34, no. 25, pp. 273-275.

PARATYPE (1): SU 13484 (orig. no. MCZ, number unknown), collected by W. M. Mann, 1916; Wainone Bay, San Cristoval Island, Solomon Islands.

(HOLOTYPE: CNHM 13715, male; Ugi Island, Solomon Islands.)

EMOIA PALLIDICEPS MAXIMA Brown, 1953, Amer. Mus. Nov., no. 1627, p. 10.

PARATYPES (4): SU 11591-11594, collected by S. G. Jewett, Jr., Feb. 8-11, 1945; same locality as holotype.

(HOLOTYPE: CNHM 43143; Hollandia, Dutch New Guinea.)

EMOIA SUBMETALLICA BOGERTI Brown, 1953, Amer. Mus. Nov., no. 1627, pp. 18-20.

PARATYPE (1): SU 13486 (orig. no. AMNH 61925), collected by the Archbold Expeditions, 1938; same locality as holotype.

(HOLOTYPE: AMNH 61911, male; Balim River Camp, Balim River, Dutch New Guinea [approx. Lat 4° 10' S., Long. 139° E.]).

FAMILY TEIIDAE

CNEMIDOPHORUS NEOMEXICANUS Lowe and Zweifel, 1952, Bull. Chicago Acad. Sci., vol. 9, no. 13, pp. 230-247, text-figs. 1, pl. 1, figs. a-c.

PARATYPES (2): SU 16104-16105 (orig. nos. MVZ 55790 and 55794 respectively), collected by C. H. Lowe, Jr., Aug. 14, 1950 and Aug. 18, 1947 respectively; same locality as holotype.

(HOLOTYPE: MVZ 55807; McDonald Ranch Headquarters, 8.7 miles west and 22.8 miles south of New Bingham Post Office, Socorro Co., New Mexico.)

SUBORDER SERPENTES

FAMILY LEPTOTYPHLOPIDAE

LEPTOTYPHLOPS HUMILIS SLEVINI Klauber, 1931, Trans. San Diego Soc. Nat. Hist., vol. 6, no. 23, pp. 338-339.

PARATYPE (1): SU 4118, collected by G. Eisen, Sept. 1893; San José del Cabo, Baja California, Mexico.

(HOLOTYPE: CAS 53721; La Paz, Baja California, Mexico.)

FAMILY COLUBRIDAE

ATRACTUS GAIGEAE Savage, 1955, Proc. Biol. Soc. Washington, vol. 68, p. 12.

PARATYPES (3): SU 15619-15620, collected by P. Mena, March 1951; Canelos, Napo-Pastaza Prov., Ecuador. SU 15621, collected by C. Fuller, April 1951, headwaters of the Rio Bobonaza, Napo-Pastaza Prov., Ecuador.

(HOLOTYPE: UMMZ 82887, male; Santiago-Zamora Prov., Ecuador.)

ATRACTUS ORCESI Savage, 1955, Proc. Biol. Soc. Washington, vol. 68, pp. 17-18.

HOLOTYPE: SU 15622, male, collected by J. Olalla, Oct. 1952; Loreto, Napo-Pastaza Prov., Ecuador.

CALAMARIA SCHMIDTI Marx and Inger, 1955, Fieldiana: Zoology, vol. 37, p. p. 197, fig. 27.

PARATYPE (1): SU 8568, collected by Mrs. Mary (Knapp) Strong Clemens, about 1931; Mount Kinabalu, British North Borneo.

(HOLOTYPE: USNM 130240, female; Bundu Tuhan, Mount Kinabalu, British North Borneo.)

CHILOMENISCUS SAVAGEI Cliff, 1954, Trans. San Diego Soc. Nat. Hist., vol. 12, no. 5, pp. 71-73, fig. 2.

HOLOTYPE: SU 14034, female, collected by J. M. Savage, April 3, 1952; on southwest coast of Isla Cerralvo, Gulf of California, Mexico.

PARATYPE (1): SU 16062; exchanged to the CAS.

DROMICUS HOODENSIS Van Denburgh, 1912, Proc. California Acad Sci., ser. 4, vol. 1, pp. 338-341, pl. 24.

PARATYPES (2): SU 4970-4971, collected by E. Heller and R. E. Snodgrass, May 14-20, 1899; same locality as holotype.

(HOLOTYPE: CAS 11799; Hood Island, Galapagos Islands.)

DROMICUS OCCIDENTALIS HELLERI Van Denburgh, 1912, Proc. California Acad. Sci., ser. 4, vol. 1, pp. 349-351, pl. 28.

PARATYPE (1): SU 4977, collected by E. Heller and R. E. Snodgrass, 1899; near Cape Berkeley, Albemarle Island, Galapagos Islands.

(HOLOTYPE: CAS 10280, male; Brattle Island, Galapagos Islands.)

DROMICUS OCCIDENTALIS OCCIDENTALIS Van Denburgh, 1912, Proc. California Acad. Sci., ser. 4, vol. 1, pp. 347-349, pl. 27.

PARATYPES (4): SU 4973-4976, collected by E. Heller and R. E. Snodgrass, Jan. 8-Feb. 9, 1899; same locality as holotype.

(HOLOTYPE: CAS 11488; Narborough Island, Galapagos Islands.)

DROMICUS SLEVINI Van Denburgh, 1912, Proc. California Acad. Sci., ser. 4, vol. 1, pp. 351-353, pl. 29.

PARATYPE (1): SU 4972, colected by E. Heller and R. E. Snodgrass, 1899; Narborough Island, Galapagos Islands.

(HOLOTYPE: CAS 12216, male; Duncan Island, Galapagos Islands.)

LYCODON SUBCINCTUS SEALEI Leviton, 1955, Philip. Jour. Sci., vol. 84, no. 2, pp. 195-198.

PARATYPE (1): SU 17715 (orig. no. CAS 15818), collected by Alvin Seale, Feb. 20, 1908; same locality as holotype.

(HOLOTYPE: CAS 15819, male; Puerto Princesa, Palawan Island, Philippine Islands.)

NATRIX VIBAKARI RUTHVENI Van Denburgh, 1923, Proc. California Acad. Sci., ser. 4, vol. 13, no. 2, pp. 3-4.

PARATYPE (1): SU 17718 (orig. no. CAS 31485), collected by V. Kühne, May 8, 1911; same locality as holotype.

(HOLOTYPE: CAS 31487, male; Fusan, Kjong-Sang-Do Prov., Korea.)

PHYLLORHYNCHUS ARENICOLA Savage and Cliff, 1954, Proc. Biol. Soc. Washington, vol. 67, pp. 69-76.

HOLOTYPE: SU 14013, male, collected by F. S. Cliff, J. M. Savage, J. P. Figg-Hoblyn, J. M. Lindberg, April 15, 1952; sand dunes along the west coast of Isla Monserrate, Gulf of California, Mexico.

PARATYPE (1): SU 14014; exchanged to the CAS.

PITUOPHIS CATENIFER RUTILUS Van Denburgh, 1920, Proc. California Acad. Sci., ser. 4, vol. 10, no. 1, p. 24, pl. 2, fig. 2.

PARATYPES (3): SU 1705, 1714, 1131, collected by W. W. Price, June 10-20, 1893 (SU 1714 collected May 25, 1893); Fort Lowell, Pima Co., Arizona.

(HOLOTYPE: CAS 33869, female; Tucson, Pima Co., Arizona.)

FAMILY CROTALIDAE

CROTALUS CATALINENSIS Cliff, 1954, Trans. San Diego Soc. Nat. Hist., vol. 12, no. 5, pp. 80-82, pl. 7, fig. 4.

HOLOTYPE: SU 15631, female, collected by B. Firstman, F. S. Cliff, and J. C. Briggs, March 27, 1953; northeast end of Isla Santa Catalina, Gulf of California, Mexico.

CROTALUS CERASTES CERCOBOMBUS Savage and Cliff, 1953, Nat. Hist. Misc., Chicago, no. 119, pp. 1-7, 1 fig.

HOLOTYPE: SU 7287, male, collected by G. M. Kranzthor and G. S. Myers, April 18, 1929; Gila Bend, Maricopa Co., Arizona.

PARATYPES (4): SU 12665, collected by J. Lamont and J. M. Savage, Sept. 4, 1949; 112° 46' W. Long., 32° 13' N. Lat., Pima Co., Arizona. SU 13997, collected by J. P. Figg-Hoblyn, J. Lamont, and J. M. Savage, July 12, 1950; 10 miles southeast of Ajo, Pima Co., Arizona. SU 12779, collected by J. P. Figg-Hoblyn, J. Lamont, and J. M. Savage, Aug. 2, 1950; 6 miles northeast of Puerto Libertad, Sonora, Mexico. SU 13999, collected by J. P. Figg-Hoblyn, J. Lamont, and J. M. Savage, July 22, 1950; 8 miles northeast of Puerto Kino, Sonora, Mexico.

CROTALUS ENYO CERRALVENSIS Cliff, 1954, Trans. San Diego Soc. Nat. Hist., vol. 12, no. 5, pp. 82-84, pl. 6, fig. 3.

HOLOTYPE: SU 14021, male, collected by J. P. Figg-Hoblyn, J. M. Savage, and F. S. Cliff, April 3, 1952; dunes on the southwest coast of Cerralvo Island, Gulf of California, Mexico.

ORDER TESTUDINATA
FAMILY TESTUDINIDAE

GRAPTEMYS FLAVIMACULATA Cagle, 1954, Tulane Stud. Zool., vol. 1, no. 11, pp. 167-173, figs. 2, 3, 5, 7.

PARATYPE (1): SU 16285 (orig. no. Tulane 14846), collected by Tulane University field crew, Aug. 18-19, 1952; same locality as holotype.

(HOLOTYPE: Tulane 14798, male; Pascagoula River, 13 miles southwest of Lucedale, George Co., Mississippi.)

GRAPTEMYS NIGRINODA Cagle, 1954, Tulane Stud. Zool., vol. 1, no. 11, pp. 173-174, 179-181, figs. 1, 4, 6, 8.

PARATYPE (1): SU 16286 (orig. no. Tulane 14647), collected by Tulane University field crew, Aug. 7, 1952; same locality as holotype.

(HOLOTYPE: Tulane 14662, female; Black Warrior River, above Lock 9, 17.5 miles south-southwest of Tuscaloosa, Tuscaloosa Co., Alabama.)

GRAPTEMYS PSEUDOGEOGRAPHICA OUACHITENSIS Cagle, 1953, Occ. Pap., Mus. Zool., Univ. Michigan, no. 546, pp. 10-16, figs. 2-3.

PARATYPE (1): SU 16288 (orig. no. Tulane 12643), collected by A. H. Chaney and C. L. Smith, June 10-19, 1950; same locality as holotype.

(HOLOTYPE: UMMZ 104345, female; Ouachita River, 4 miles northeast of Harrisburg, Louisiana.)

GRAPTEMYS PSEUDOGEOGRAPHICA SABINENSIS Cagle, 1953, Occ. Pap., Mus. Zool., Univ. Michigan, no. 546, pp. 2-10, figs. 1, 3.

PARATYPE (1): SU 16287 (orig. no. Tulane 13760-23), collected by A. H. Chaney and C. L. Smith, July 6, 1950; same locality as holotype.

(HOLOTYPE: UMMZ 104351, female; Sabine River, 8 miles southwest of Negreet, Louisiana.)

NATURAL HISTORY MUSEUM, STANFORD UNIVERSITY,
STANFORD, CALIFORNIA.

Amphibians and Reptiles of the North Rim, Grand Canyon, Arizona

By Floyd E. Durham

While studying small mammals on the North Rim of the Grand Canyon, Arizona (Durham, Variations in the rodents of the North Rim of the Grand Canyon, Arizona, *in* Essays in the Natural History Sciences in honor of Captain Allan Hancock, Univ. of So. Calif. Press, Los Angeles, 1955) in 1947 and 1949, I spent some time in observing and collecting amphibians and reptiles. Collecting stations have already been described and located (Durham, *op. cit.*) and most of them are shown on the Grand Canyon National Park topographic map (U. S. Dept. Int. Geol. Surv.). Half of the specimens are at the Hancock Foundation, University of Southern California, and half are at the Naturalists' Workshop, South Rim, Grand Canyon, Arizona.

The field work was made possible through the generosity of Captain Allan Hancock of the Hancock Foundation. Dr. Frederick A. Shannon, Wickenburg, Arizona, and Mr. Laurence M. Klauber, San Diego Society of Natural History, checked the identification of specimens. Dr. Fred S. Truxal, Los Angeles County Museum, identified the stomach contents. I am indebted to Dr. Charles H. Lowe, Jr., University of Arizona, for reading the manuscript.

Ambystoma tigrinum utahense Lowe

The tiger salamander is the only salamander known to occur on the North Rim. In early summer, at least, larvae may be found in most pools and lakes in or near aspen forest. These small bodies of water usually have oozy, muddy bottoms, and weedy margins and the water may be colored by pine needles. Without special netting equipment but few adults were collected. Most of these were found dead. A shriveled female was picked up on the muddy bank of Coffee Lake on July 4. Strings of dried mucus, as if from ovulation, were protruding from the vent. Another adult was found dead on the mudcracked floor of a nearly dry pond in an exposed, treeless area just outside the North Entrance. A third was taken from the stomach of a garter snake (*Thamnophis e. vagrans* (B & G) at Greenland Lake. The flesh of the anterior end of this salamander was digested, presenting a nearly cleaned cranium. The fourth adult was the unexpected result of subsequent experimentation in California. The then immature specimen, along with several other larvae with head-body length of 40 mm., was obtained from Neal Spring on July 18. I was able to keep this one alive, and, on reaching home (Los Angeles County) I put it in a small water trough where I kept it until it died six weeks later. In this small environment the temperature and volume of water fluctuated which stimulated metamorphosis with no noticeable increase in head-body length. The tail shortened nearly 10 mm. with the loss of the caudal fin, the gills disappeared and the head took on a nearly circular outline. It was then 62 mm. in total length and weighed 2.5 gr.

The specimen from Greenland Lake had three recently ingested dragon fly nymphs (*Aeschnidae*) in its stomach. Greenland Lake has marginal vegetation favorable to aquatic insects. The specimen from the

North Entrance had the remains of winged carpenter ants (*Camponotus* sp.) and the head of a Dytiscidae water beetle (*Agabus* sp.) in its stomach. Two muscoid fly larvae (at least one was Sarcophagidae) were found in the coelom but I think they were not ingested but were the result of fly-infestation after death. The environment offered but little attraction for arboreal insects.

Salamander larvae of 70 mm. total length were observed to feed on insects floating on the surface of the small pond at Neal Spring. Other insects, on floating aspen leaves, were picked off by the larvae which, on descending, shook the prey as a dog does a rat.

The female salamander found July 18 at Greenland Lake contained eggs in various stages of development in two 30 by 6 mm. oviducts. The largest eggs, 1.75 mm. in diameter, were black, those at 1 mm. were gray, and the .5 mm. eggs were whitish. Judging from the size of the larvae taken in early July, egg laying must begin much before this date.

The smallest larvae taken were 31-32 mm. in total length. These were collected on July 4 at a small pool near the Harvey Camp. One specimen had only the front legs but the other had, in addition, hind leg buds 2 mm. long. In these larvae, the tail was slightly more than one-third the total length.

A middle-sized (49-75 mm. total length) group of larvae was collected from July 4 to July 18 at Coffee Lake, Neal Spring, Greenland Lake and the pool near Snowshoe Cabin. On these specimens the hind legs were well developed and the tail was relatively long (nearly one-half total length). It is thought that the above two groups were first-year larvae having hatched from eggs laid in the preceding spring.

A large-sized group of larvae was found on July 12 at Swamp Lake. The tail was still almost one-half the total length of 95-100 mm. The external gills and caudal fin were of full size. It is thought that these were second-year larvae nearing the time to reproduce as axolotls or to metamorphose.

Scaphiopus hammondi intermontanus Cope

The spadefoot toad is the only tailless amphibian recorded from the North Rim. The larvae are commonly seen in late June and July in Greenland Lake and I also found them in Coffee Lake and in the pool near Snowshoe Cabin. At Swamp Lake they occurred with *Ambystoma* larvae, both numerous, apparently without competition. Adult toads were rarely seen. Two horsemen, caught in an afternoon rain storm at Swamp Lake in early July, reported numerous frogs (presumably spadefoot toads) there. One adult 29 mm. long accidentally hopped into and was caught by my mouse trap baited with rolled oats set at the rail fence at that lake on a rainy night. One subadult, collected at Greenland Lake, had a 3 mm. stub tail but otherwise possessed adult characters. The head-body length was 25 mm., but little longer than that measurement for tadpoles. Immatures with hind legs only, measured up to 22 mm. and those with four legs up to 23 mm. The characteristic single left spiracle, short (12-15 mm.) hind legs, and horny beaks were found on young tadpoles without front legs. As the tail shortened (from 56 per cent to 50 per cent of total length) the hind legs lengthened (from 12

mm. to 16 mm.) until at metamorphosis the legs were approximately of head-body length.

When the front legs broke through (one through the spiracle) there was then a breathing port on each side. At this stage the tail was less than one-half the total length and the hind legs had increased to 16-22 mm. and the horny beaks had been lost. One specimen with four legs and a reduced tail (further shortened by predators) had a head-body length of 23 mm., a hind leg of 22 mm., and an adult-like mouth except the slit extended only half way back.

Tadpoles are cannibalistic, particularly when crowded into a small aquarium. Whenever one member of the confined lot lost its agility or died it was quickly attacked by the others which started nibbling on the tail first.

Sceloporus graciosus graciosus Baird and Girard

The sagebrush lizard occurs on brushy, rocky areas at the edge of, or just below, the North Rim. It was collected at only two stations, six specimens from Point Honan, where they were shot while sunning on boulders, and three from Muav Saddle and vicinity, where they occupied stones along the trail from Swamp Point.

The throat was pale blue (reticulated in one specimen). Longitudinal dorsal stripes were not conspicuous. The dorsal scales were numerous (51-55) and approached the maximum number for the subspecies.

Sceloporus undulatus tristichus Cope

The southern plateau lizard was found sparingly on large rocks on Dutton Point, at Muav Saddle and on the trail from Swamp Point to Muav Saddle. Only three specimens were taken. Two were typical in coloration. The third, from Dutton Point, had only a trace of dorsal pattern (indistinct lateral and transverse lines) and the pale blue, unmargined belly patches almost touched anteriorly. In color the latter specimen resembled the brown phase of the southern prairie lizard (*S. u. consobrinus*); the snout-vent length is 60 mm.

Phrynosoma douglassii hernandesi (Girard)

The mountain short-horned lizard is common on the North Rim. Four of the seven taken were from Swamp Point which is an exposed, brushy, Upper Sonoran area. Two were taken in or near Canadian Forest at Robber's Roost. The other was taken at the Bright Angel Ranger Station where others were seen but not collected. These specimens agree with the description of the race *hernandesi* and show but little variation from the few specimens examined from the South Rim. However, these specimens from the Grand Canyon contrast sharply with the single specimen taken in yellow pine timber near Flagstaff, Arizona. This latter specimen seems unusual in having heavier black pigment which makes the nuchal and dorsal spots scarcely distinguishable, the occipital horns and the superciliary-canthal ridge are less prominent, the dorsal spines are fewer and smaller, the claws are long (3.5 mm.), and the femoral pores (16-17) are separated by four preanal scales. In the number and separation of femoral pores this specimen resembles *P. d. ornatissimum* which occurs some 100 miles to the eastward.

The adaptation of color to the environment is clearly shown even in preserved specimens. The blackish specimen from the shady, timbered area near Flagstaff was taken early in the morning. The specimen taken

at midday from the red, barren landing strip at the Red Butte Airport near the South Rim is pale and particularly reddish about the head.

Cnemidophorus velox Springer

The plateau whiptail can hardly be considered an inhabitant of the North Rim proper. None was seen here and the four taken were on Muav Saddle at 6717 feet elevation. They were found foraging somewhat noisily among the leaf litter under the locust brush in the Upper Sonoran Life Zone. They were not difficult to shoot because they allowed me to approach within a few yards before they made a short, rather leisurely run.

My specimens, apparently adults, measure 72-75 mm. snout-vent length. They have retained the juvenile, striped (including the median dorsal stripe), unspotted body pattern.

Pituophis catenifer deserticola Stejneger

The Great Basin gopher snake is the most common and the largest snake of the North Rim. It has been taken in brush land, forest margins and near buildings. One specimen was collected near the Bright Angel Ranger Station, 8200 feet elevation. Another was collected near the cabin at Muav Saddle, 6717 feet elevation. This latter locality extends the known range some 18 miles to the westward from Farview Point (110° 15' N, 111° 59' W), also on the North Rim. Two more gopher snakes were sighted by members of the party near Dutton Point, approximately 7600 feet levation, on Powell Plateau. One of the latter snakes, of medium size, was observed in the branches of the locust shrub (*Robinia neomexicana*) outside the yellow pine forest. These large snakes have mild dispositions and may be readily handled. One served me well at a campfire demonstration.

The two I collected on the North Rim measured 1640 and 1440 mm., respectively. Apparently the gopher snakes (both *deserticola* and *catenifer*) in California, Nevada, Utah, Arizona and Colorado near latitude 35-37° N. attain a very large size.

The smaller of my two specimens from the North Rim is typical in color and pattern for *deserticola*. The larger specimen has browner spots and yellower interspaces and a pink tinge on sides and ventral surfaces.

The smaller specimen has a high count on ventrals (247) and subcaudals (70), postoculars (3), supralabials (9), and infralabials (12), but only a single preocular, which characters are appropriate for those *P. c. deserticola* of northern Arizona. A single median azygous scale occurs between the frontal and the two prefrontals. The specimen is near the upper limit in number of blotches, having 70 on the body and 17 on the tail.

The Hancock Collection contains a single specimen of *P. c. deserticola* from Park Headquarters on the South Rim. It is an adult (1640 mm. total length) intergrade but near *P. c. deserticola* with 61 spots on the body and 17 on the tail, 243 ventrals, 68 subcaudals, and a rostrum 6 by 6 mm. It resembles *P. c. affinis* Hallowell in that the black longitudinal neck stripes are poorly developed, the neck and tail blotches are not clear black and the anterior ones are tinged with brown; there is but little black on the keels of scales in the anterior interspaces and the ventral surface is pinkish. The prefrontals number four. Furthermore, this

snake is peculiar in having both the 5th and 6th supralabials (of 9) reaching the eye, and in having the 8th the largest.

Thamnophis elegans vagrans (Baird and Girard)

The wandering garter snake is common around pools, streams and lakes at the eastern end of the North Rim and may occur well away from sites of permanent water. Specimens were taken at Greenland Lake, Neal Springs, and Bright Angel Ranger Station. None was seen at Robber's Roost, Coffee Lake, and Swamp Lake although the environment seemed ideal for them at least as far as food (salamanders and toads) was concerned.

Specimens varied from 300 to 750 mm. in total length with a tail 17 to 23 per cent as long. In general, they possessed faint striping. The smallest one, from Neal Springs, was unusual in having spots overshadowing the striping, possibly a juvenile character, and a long, narrow head (ratio of width to length is 53 whereas the average for the three others is 68), a long tail (the relatively longest tail of the four specimens), and a suture on the anal plate.

Most of these snakes were found in wet places near amphibian larvae. They eat adult salamanders as recorded under the account of *Ambystoma tigrinum*.

Crotalus viridis lutosus Klauber

A single specimen of the Great Basin rattlesnake was taken in the Grand Canyon. It has been collected in the Grand Canyon National Monument. This specimen extends the known range some 35 miles to the eastward. It was collected near the spring locally known as the Muav Spring, ¼ mile southeast of Muav Saddle. The snake was first observed at dusk coiled beside the trail. I passed without noticing it but its buzzing terrified my son following behind me so that he dropped his canteen which caused the snake to retreat quickly into the brush where it could not be found. However, the following morning it was again beside the trail where it was shot. The specimen in life was typical of the race with well-defined body blotches on a greenish drab background.

Crotalus viridis abyssus Klauber

A single specimen, 1025 mm. long, of the Grand Canyon rattlesnake was collected near Powell Spring in Saddle Canyon to the north of Muav Saddle at 6250 feet elevation. It was collected by Dr. Norman C. Cooper, a member of the party and then a member of the Hancock Foundation staff. On the same day I was at Dutton Point, Powell Plateau, where, under a stone, I found part of a shed skin (anterior end missing) of a rattlesnake. The scale characters were sufficiently distinct to allow classification as *C. viridis*. Because traces of salmon pink pigment were still visible between the scales it is assumed that the specimen belongs to *abyssus*. It was further assumed that all the *C. viridis* of the vicinity were also of this race, which assumption proved false two years later when a specimen of *C. v. lutosus* was taken at Muav Spring (see previous account). Apparently Muav Saddle is a zone of overlapping for *abyssus* and *lutosus*. One would expect to find *abyssus* on the south exposure and *lutosus* on the north exposure but the reverse was true with the two specimens taken.

ALLAN HANCOCK FOUNDATION, CONTRIBUTION 175,
UNIVERSITY OF SOUTHERN CALIFORNIA, LOS ANGELES

Food Habits of the San Diego Alligator Lizard

By JOHN D. CUNNINGHAM

While engaged in ecological studies on the San Diego alligator lizard (*Elgaria multicarinata webbi* Baird), the writer had occasion to study the food habits of several species and subspecies of alligator lizards. The name *Elgaria* rather than *Gerrhonotus* is employed in accordance with Tihen (1949, Amer. Midl. Nat., 41: 580-601). A total of 396 stomachs were examined. Of the 96 Coronados alligator lizards (*Elgaria m. nana* Fitch) analyzed, 76 were from South Island, 4 from Middle Island and 16 from North Island in the Coronados Islands. The 38 red-backed alligator lizards (*Elgaria m. multicarinata* Blainville) were distributed as follows: 8 were from San Miguel Island, 19 from Santa Cruz Island, 1 from San Clemente Island, 6 from Santa Rosa Island and 4 from the mainland in Santa Barbara County, California. The *E. m. webbi* had been captured in southern California and northern Baja California. Because no differences in food preferences were detected among the lizards from the various island populations, each subspecies is discussed in its entirety.

The writer wishes to thank Drs. Raymond B. Cowles and Laurence M. Klauber for permission to examine specimens from collections in their care. In addition, Dr. Cowles has assisted in preparation of the manuscript and Mr. Bayard H. Brattstrom aided in making certain stomach analyses.

The stomach of each lizard was removed and the contents were dispersed in water and examined under a low power microscope. Internal parasites were collected and presented to Dr. Clark P. Read of Johns Hopkins University. Because no special search was made for parasites, the percentages of parasitism indicated in Table I are probably low. With the exception of a single trematode all the internal parasites were nematode worms.

TABLE I

CONTENTS OF DIGESTIVE TRACT IN *E. MULTICARINATA*

	multicarinata	*nana*	*webbi*
Number examined	38	96	262
Number empty	3	28	76
Animal: Number	34	64	181
Percentage	97.1	94.1	97.3
Plant: Number	3	14	36
Percentage	8.6	20.6	19.s
Mineral: Number	6	13	91
Percentage	17.1	19.1	48.9
Parasites: Number	8	8	9
Percentage	21.0	8.3	3.4

Mineral matter, generally in the form of sand or small pebbles, was present to some extent in all subspecies and especially in *E. m. webbi*, where the incidence was 48.9% (Table I). In the latter subspecies, some stomachs contained almost solely sand and were quite distended. The prevalence of mineral matter under these conditions hints that not all had been consumed incidentally during normal feeding. However, no correlation was noted between those lizards with internal parasites and

the presence of other than minute amounts of mineral matter. Some of the insular lizards, both of *E. m. multicarinata* and *E. m. nana*, had small fragments of worn shell in their stomachs, indicating possible foraging about the beach. Plant material (miscellaneous particles of stems, twigs, leaves, etc.) was likewise present in some lizards of all subspecies analyzed but probably had been consumed incidental to feeding.

No percentages comparing the number of empty specimens to the total number examined were determined because alligator lizards are ordinarily not preserved immediately after capture. Over 100 additional specimens, mostly of *E. m. webbi*, had been rejected since they were suspected of having been kept in captivity.

Various authors have reported on food habits of several subspecies of *E. multicarinata*, in most instances observations being based upon captive specimens. These observations are useful in studying the sensory cues employed in discerning or selecting food but are of little value as a source of information on natural diets. For instance, Gander (1931, Copeia: 14-15) found that his captives fed upon young *Sceloporus occidentalis* and *Mus musculus*, as well as insects, but refused pigeon eggs and young *Rattus*. One of his lizards attempted to eat a *Hyla regilla* but was apparently greatly irritated by its dermal toxins and soon dropped the tree-frog. Upon infrequent occasions the writer has observed his own captive lizards eating *H. regilla* and certain other amphibians but *Batrachoseps attenuatus* were frequently eaten with seemingly no ill effects. However, in non-captive individuals no amphibian material of any kind was noted. Therefore, although frequency of normal feeding upon amphibians is unknown, it is suspected to be rare. Knowlton (1949, Herpetologica, 5: 46-47) listed food found in the digestive tracts of 12 *E. m. multicarinata* from Santa Rosa Island as predominantly tenebrionid beetles and spiders, with other insects composing the remainder of the diet. Christenson (1947, Herpetologica, 4:2) relates an instance of an *E. m. webbi* having died while attempting to eat a Jerusalem cricket (*Stenopelmatus*).

In most instances of feeding, movement of prey appears to be a necessary aid to identification or as a feeding stimulus. The more conspicuous the movement, the greater the reaction of the lizards. The lizard generally approaches the moving object slowly and investigates it with its tongue. If the object appears edible the lizard then arches its back upward, straightens and stiffens the forelegs and bends the head and neck sharply downward so that it strikes the prey from above with a swift vertically downward stroke. If the prey struggles the lizard resorts to a varied number of tactics, and because of a repetition of the same movements these can be considered as adaptive behaviorisms. The lizards twist and rotate with the animals in their mouth, beat their prey against any object in the immediate area, crush it against the substratum or run head-on into any nearby obstruction while still carrying the prey in its mouth, apparently in an attempt to batter the animal. These behaviorisms seem to merge imperceptibly into defensive actions. With large captives the lizard generally attempts to secure the head on the first lunge but if this fails it will gradually work its jaws toward the head or drop it and try again. Smaller objects are eaten without regard to their orientation. If the object which the lizard holds in its mouth has disagreeable secre-

tions, such as those of an amphibian, slug or certain beetles (*Eleodes*, etc.), it is dropped and the lizard moves about the cage obviously irritated and attempts to rid itself of the mucus, toxins, etc. by rubbing its mouth sideways against any available object. Later, if the same object is still alive and continues to move about the cage, the lizard frequently again cautiously approaches and investigates it but generally does not attempt to consume it again.

TABLE II

INVERTEBRATE STOMACH-CONTENTS IN *E. MULTICARINATA*

Item	*multicarinata*	*nana*	*webbi*
Mollusca: Pulmonata	—	—	3
Arthopoda: Unidentified	—	1	—
Spiders: Total	6	5	20
Aglenidae	1	—	2
Theraphosidae	—	—	1
Theridiidae	—	—	2
Scorpions	1	1	4
Centipedes	—	2	6
Isopods	1	1	16
Total arthropods (other than insects)	8	10	46
Insects: Unidentified:	9	20	71
Orthoptera: Total	13	16	88
Unidentified	1	1	11
Blattidae	—	—	3
Gryllidae	—	—	2
Locustidae	5	5	32
Tettigoniidae	7	10	40
Odonata	—	—	1
Coleoptera: Total	24	59	120
Unidentified	3	18	41
Larvae	—	8	9
Buprestidae	—	—	3
Cantharidae	—	—	1
Carabidae	15	28	51
Coccinellidae	3	2	4
Curculionidae	—	—	3
Elateridae	—	—	2
Histeridae	1	—	—
Scarabeidae	1	2	2
Tenebrionidae	—	1	4
Diptera: Total	2	5	31
Unidentified	1	—	11
Asilidae	—	—	5
Muscidae	—	2	4
Tabanidae	—	—	2
Tipulidae	1	3	9
Lepidoptera: Total	20	8	35
Larvae	16	8	25
Heterocera	2	2	6
Rhopalocera	2	—	4

Hymenoptera: Total	4	13	28
Unidentified	1	1	4
Formicidae	1	11	17
Ichneumonidae	—	—	3
Apoidea	2	1	4
Hemiptera: Total	3	5	7
Unidentified	1	1	4
Corizidae	—	—	1
Membracidae	1	1	—
Pentatomidae	1	3	2
Homoptera: Cicadellidae	—	1	—
Neuroptera: Rhaphididae	—	—	1
Dermaptera	1	—	—

Non-moving food is taken quite frequently, however. Cowles (1937, Science, 85: 99-100) reported *E. m. webbi* to consistently discriminate between empty and egg or spiderling-filled egg cases of the black-widow spider (*Latrodectus mactans*). In the present analyses several spider egg cases were found. Fitch (1935, Trans. St. Louis Acad. Sci., 29: 1-38) reports finding fragments of egg shells in the stomach of an *E. m. multicarinata* and Grinnell and Grinnell (1907, Throop Inst. Bull., 35: 1-64) suspected that a pair of disturbed wren-tits observed in the presence of an *E. m. webbi* were protecting a hidden nest. Because of the arboreal proclivities of the species, the lizards might logically be suspected of utilizing bird eggs as food during the spring and summer months. However, no evidence for this was noted in the stomach contents of those lizards analyzed. The writer has observed captive lizards feeding upon carrion in the form of Jerusalem crickets (*Stenopelmatus*), carabid beetles, tarantulas (*Eurypelma*), *Uta stansburiana, Sceloporus occidentalis, Elgaria multicarinata* and baby mice, all of which had been dead for at least one day and in some instances for as many as four days before being eaten. It is suspected that even in nature these lizards occasionally eat carrion.

When approaching non-moving prey or other objects the lizards commonly stop occasionally and move their heads vertically in a manner similar to the head bobbing of iguanid lizards, in small circles or, most frequently, in a horizontal pattern. It is possible that this enables the lizard to see non-moving objcts from various angles and thus produce parallax which results in judgment of the object's size, depth and distance.

Only a single black widow spider was found, in the stomach of an *E. m. webbi*, during the course of this study. Cowles (1937, *op. cit.*) gives an interesting discussion regarding the San Diego alligator lizard as the probable major predator upon this spider. Spiders of various kinds were generally found in the stomachs of every form studied but never appeared to constitute a major food item.

Vertebrates, mainly lizards, were found in the diet of all subspecies of *Elgaria multicarinata* studied. With the exception of other alligator lizards, the Western skink (*Eumeces skiltonianus*) was the commonest lizard represented in the stomach contents. In several cases only the tail was present, a not unexpected phenomenon in lizards so prone to autotomy. Cannibalism was noted in a total of 9 lizards. Gander (1934,

Copeia: 187) had noted cannibalism in captive *E. m. webbi* and the writer has since noted it in captives on numerous occasions. Size is no great deterring factor in this regard, several instances having been noted in which the prey was actually of greater total length than the predator. Gander (1934, *op. cit.*) was impressed that a 306 mm. female consumed a 282 mm. male.

The relatively low temperature tolerances of this species and its large size are probably the main factors allowing these relatively slow-moving lizards to capture and eat the swifter skinks and iguanids. While the latter species are inactive due to low body temperatures, the alligator lizards are well within their eccritic temperature range and are thus able to crawl into the retreats of the above species and easily consume them. A pair of captive lizards were observed by the writer to be engaged in normal mating activity when the male, which was characteristically holding the female with his mouth in her neck region, proceeded to work his mouth toward the female's head and commenced to swallow her. Perhaps in this instance the stimulus of a possible food object in the mouth was at the time stronger than the mating instinct. In another instance of cannibalism observed in captivity, a large lizard began at the opposite end of a juvenile *Sceloporus occidentalis* which a smaller alligator lizard had already half consumed and proceeded to swallow both the *Sceloporus* and the other *Elgaria*. In captivity, alligator lizards will attack and attempt to eat almost any vertebrate species of reasonable size. An instance of a 113 mm. *E. m. webbi* swallowing a 75 mm. *Phrynosoma coronatum* has even been observed. Because the lizards are generally attracted to movement, it is surprising that lizards, especially juveniles, were not more frequently encountered in the stomach analyses.

TABLE III

VERTEBRATE STOMACH-CONTENTS IN *E. MULTICARINATA*

Item	*multicarinata*	*nana*	*webbi*
Lizard: Total	1	10	17
Elgaria multicarinata	1	3	5
Eumeces skiltonianus	—	5	3
Sceloporus graciosus	—	—	2
Sceloporus occidentalis	—	1	4
Uta stansburiana	—	1	3
Mammal	—	—	2
Bird	—	1	2

Small mammals and birds were observed in the stomach contents of several lizards (Table III) and are readily eaten by captive lizards. Fitch (*op. cit.*) and Grinnell and Grinnell (*op. cit.*) have also listed warm-blooded prey as part of the diet of this species.

Scorpions, centipedes and isopods (mainly sowbugs) were noted in the stomachs of non-captive lizards and these are also readily eaten by captives. However, insects were the main constituent in the diet of all subspecies examined. While beetles were the most frequently encountered insects, being found in approximately half of the stomachs of each subspecies analyzed, the orthopterans (especially the Tettigoniidae and Locustidae) constituted the greatest volume of the insect diet. The majority of the Tettigoniidae were Jerusalem crickets (*Stenopelmatus*). Thus,

it appears that beetles and orthopterans are the major insects in the diet of this species, with other forms taken as available. It does not appear that the lizards exhibit a preference for the above, however. The general availability and abundance of these insects make them the ones most frequently encountered by the foraging lizards. No food preferences were detected that could not be explained on the basis of seasonal availability.

Stebbins (1954, Amphs. Repts. W. N. Amer.) cites observations made by Charles Bogert that captive alligator lizards entered water and consumed tadpoles. A similar experiment conducted by the writer showed that *E. m. webbi* would readily enter water and eat the tadpoles of *Hyla regilla* and *Bufo boreas* in captivity. In the light of these observations, certain instances of finding alligator lizards swimming might be explained.

SUMMARY

The stomachs of 396 alligator lizards (*Elgaria multicarinata*) were examined. Included in the study were representatives of the subspecies *multicarinata, nana* and *webbi*. Observations on food habits of captive lizards are discussed. Insects are the main constituents in the diet of the alligator lizard but other arthropods and vertebrates are also eaten.

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ADDITIONAL RECORD OF THE COAL SKINK IN KENTUCKY.—Funkhouser (1925, Ky. Geol. Surv., Series 7, 14: 79) listed the coal skink, *Eumeces anthracinus* (Baird) from Bell, Knox, and Harlan counties in Kentucky.

Hibbard (1936, Trans. Kans. Acad. Sci., 39: 280) recorded a specimen from Mammoth Cave Ridge (Edmonson county).

Smith and Smith (1952, Uni. Kans. Sci. Bul., 34 (2); 685) examined two Kentucky specimens, from Bell and Edmonson counties. The Edmonson county specimen is undoubtedly the same as that mentioned by Hibbard, and possibly the Bell county specimen is one mentioned by Funkhouser.

In summary, the coal skink is known from Kentucky by two specimens from different counties, and by presumably sight records from two additional counties. With the exception of the Edmonson county record, all Kentucky records of the occurrence of this species are from three adjacent counties in extreme southeastern Kentucky.

On June 22, 1955, an adult male coal skink was taken on the lawn of the Robinson Recreation Camp near Noble, Breathitt county, at an elevation of about 850 feet. This locality is some fifty airline miles north-northeast of Bell county.

When found, the animal was running through the closely-clipped grass. It is now deposited in the zoological collections of the University of Kentucky. The specimen agrees with the characteristics of *Eumeces a. anthracinus* (Baird) as given by Smith and Smith (op. cit.).—*Roger W. Barbour, Dept. of Zoology, Univ. of Ky., Lexington.*

Food Habits of the Texas Dwarf Siren

By JOHN B. SCROGGIN and W. B. DAVIS

Perhaps the food habits of few animals are less known than those of salamanders of the genus *Siren*. The reason for this is that few herpetologists are equipped to capture them and, secondly, the animals are highly secretive. Le Conte (1824) is perhaps the first author to make any recorded statement when he reported only "mud" in specimens he examined. Dunn (1924) reported that specimens he examined had been eating algae and diatoms. He further stated that "sirens eat only algae and diatoms in a natural state." Algae, exoskeletons of crustaceans, and shells of bivalves were in the feces of captive sirens observed by Noble and Marshall (1932) in Arkansas. Stomachs of sirens examined by Cagle and Smith (1939) in Illinois in January were empty. Hurter (1911), working in Missouri, stated that sirens fed upon worms and minnows. Of twelve stomachs of young sirens examined by Carr (1940) in Florida, six contained plankton, amphipods, cranefly larvae and pupae, and lumbriculid worms. Hamilton (1950) reported that in Florida *Siren lacertina* Linnaeus feeds mainly on snails and insects, while Burch and Wood (1955) reported small clams and snails in the stomach of a single specimen of *S. lacertina* from Virginia.

The only previous study involving the examination of large numbers of sirens was that by Davis and Knapp (1953) at College Station, Texas. They examined 116 specimens, 30 of which contained food in the large and/or small intestine. The stomach in all specimens was empty. Of the 30 containing food items, 25 (83.3 per cent) had consumed large quantities of vegetation, chiefly filamentous algae and submerged plants resembling water milfoil (*Myriophyllum*), as well as bits of debris; 16 (53.3 per cent) had ingested midge larvae (Chironomidae); 13(43.3 per cent), had eaten mayfly larvae. Other animal items include two water mites, two snails, and four caddis fly pupae.

Investigation of the food habits of the Texas dwarf siren (*Siren intermedia nettingi* Goin) was undertaken because of controversy in the literature concerning the subject, because the animals were readily available, and because of the conspicuous absence of life history data on this salamander. Preliminary work was begun in September, 1952, with seinings in several ponds in the immediate vicinity of College Station, Texas. Country Club Lake was finally chosen as the chief study area because it was nearby, relatively large, and the shores were accessible. Sampling was carried on from September 25, 1952, to September 13, 1953.

METHODS AND TECHNIQUES

Information on the habits of sirens indicated that, like most salamanders, they were nocturnal; therefore, initial attempts to capture them were made at night with a seine of one-quarter inch mesh, 4 feet deep and 20 feet long. Since no sirens were caught in September and October, 1952, two traps of a multiple funnel type were constructed and placed in the pond on November 1. These were not effective in capturing sirens, but did capture several musk turtles (*Sternotherus odoratus* Latreille), particularly when small fish became entangled in the mesh and died.

These traps were not removed until a large number of sirens had been captured by other means.

Seining was continued from September through the fall period but no sirens were caught until December 19. It was found that the addition of a heavy chain to the bottom of the seine prevented the escape of sirens, especially in vegetation. Another ameliorating factor was the lifting of the lower part of the seine on the drag-out near the shore. This expedient was employed also in dense vegetation or when unfavorable conditions existed on the bank.

Rotenone was not used in Country Club Lake, but it was used in a pond in Wellborn with negative results. Davis and Knapp (1953), however, used it successfully in another pond in Brazos County. This method is not immediate in its effects on sirens, it is expensive, and all of the sirens in the pond may be affected, hence it was not used to obtain specimens in this case.

The sirens once captured were placed in a killing jar and returned to the laboratory. They were rinsed off, placed in a large dissecting pan and kept in a refrigerator until time was available for removing the stomach and intestinal contents. These were removed and stored separately in the same solution in which bottom samples were stored. A higher degree of preservation was obtained if the contents were agitated in clean water, the solids allowed to settle, the water drained off, and then the preservative added. This last procedure is for material which is to be kept longer than a month. The volume of the stored samples was obtained by following the procedure outlined by Ball (1948, p. 12).

Water, as well as air, temperatures were taken in conjunction with weekly seinings. Water temperatures were recorded only for the shallow littoral section because that was the only area in which it was possible to operate. Measurements of precipitation were obtained from the Weather Bureau of the Texas Agricultural Experiment Station, College Station. Other data, such as water level of the pond and wind direction, were simply observed and recorded.

ANALYSIS OF FOOD HABITS

Stomach versus intestinal contents. The 91 sirens used in this study were captured between December 19, 1952, and May 15, 1953, a period of approximately six months. The stomach contents were stored and analyzed separately from the intestinal contents. In certain animals, the rate of digestion may be reflected by the similarity or disparity of the contents of the stomach and the intestines. Furthermore, different items may be digested at different rates. Soft foods may be digested sooner than hard foods. Certain parts that are difficult to digest may be retained and accumulated in one part of the digestive tract. It would appear that the stomach contents would be more likely to present a truer picture of an animal's food habits, disregarding the fact that accumulated objects may be present. Intestinal contents were also used because the ascertainment of accumulation would have been difficult without both parts, because certain rare items might appear in the intestines which were not present in the stomach, and because the study of Davis and Knapp (1953) was based solely on the intestines (all stomachs were empty).

Table I presents the results of the separate analyses of stomach samples. There is little basis for comparison of totals for the

TABLE I

ANALYSES OF CONTENTS OF THE STOMACHS OF 91 SIRENS GIVING NUMBER, VOLUME AND FREQUENCY OF OCCURRENCE, WITH RESPECTIVE PERCENTAGES OF THAT SECTION'S TOTAL FOR EACH CATEGORY

Category	No.	%	Vol. cc	%	Fr.	%
Algae			10.4	9.2	48	52.7
Grass			22.3	19.3	13	14.3
Miscellaneous Plants			0.1	*	4	4.4
Total Plants			32.8	28.5	50	54.9
Gastropods	141	3.3	5.4	4.7	33	37.4
Annelids	39	.9	8.0	6.8	7	7.7
Crustaceans	3,446	81.5	5.2	4.5	19	20.9
Insects	515	12.0	11.1	9.6	62	68.1
Miscellaneous arthropods	2	*	tr.	*	2	2.2
Total invertebrates	4,143	97.7	29.7	25.6	77	84.6
Siren eggs	98	2.3	6.1	5.3	4	4.4
Mucus			0.8	0.7	5	5.5
Debris			46.1	39.9	82	90.0
Total	4,241	100.0	115.5	100.0		

*less than 0.5%

different measures except to show that the intestines held about four times the volume and about seven times the number of items found in the stomachs. Since the total capacity of the intestines is about five to six times that of the stomach, these figures are not unreasonable. The sums of frequencies show a 25 per cent higher incidence of occurrence in the intestines as compared with the stomach. It would appear from this fact that frequency of ocurrence, if used alone, would be a better measure for the intestines than for the stomach if either were analyzed separately.

Differential digestion is apparent in some foods, for example in annelids and siren eggs. Both of these soft foods are broken down completely before they leave the small intestine. Less obvious but equally applicable to this category are some of the other invertebrates. When the number of individuals is divided into the mass, a greater weight per individual is obtained for those in the stomach as compared with those in the intestines. Insects are exceptions to this rule.

The marked increase in debris of about 10 per cent in the intestines, as compared with the stomach, is attributable to the digestion and absorption of the foods in the intestines.

There appears to be a slight decrease in the total volume of plants in the intestines as compared with the stomach but it will be noted that grass was the category most affected, with a difference in volume of about 4 per cent. Grass in the large intestine was practically identical in appearance with that in the stomach. Therefore, digestion of grass by sirens is not likely.

Accumulation of food does not appear to have been operative in the

sirens examined. Indeed, it is believed that digestion must take place rapidly in these animals. By morning, three captive sirens had expelled as feces the remains of all food taken the night before. Considering that most of the specimens were taken around 11 p.m. to 12 m., complete elimination of food was effected within seven hours at air temperatures of about 70° F. This fact, plus the even distribution of food in the digestive tract, practically rules out accumulation in this case.

TABLE II

ANALYSES OF CONTENTS OF THE INTESTINES OF 91 SIRENS GIVING NUMBER, VOLUME AND FREQUENCY OF OCCURRENCE, WITH RESPECTIVE PERCENTAGES OF THAT SECTION'S TOTAL FOR EACH CATEGORY

			Vol.			
Category	No.	%	cc	%	Fr.	%
Algae			43.1	10.0	60	66.0
Grass			64.5	15.0	18	19.8
Miscellaneous plants			0.4	*	4	4.4
Total plants			108.0	25.0	62	68.1
Gastropods	1,650	5.0	55.3	13.1	64	70.3
Annelids	10	*	1.1	0.4	5	5.5
Crustaceans	25,405	91.4	20.5	4.8	33	37.4
Insects	1,013	3.6	23.9	5.6	75	82.4
Miscellaneous arthropods	8	*	0.3	*	5	5.5
Total invertebrates	28,085	99.0	101.1	23.9	87	95.6
Siren eggs	28	*	1.7	.4	3	3.3
Mucus			0.5	*	3	3.3
Debris			216.5	50.7	89	97.8
Total	28,114		427.8	100.0		

*less than 0.5%

Total Food Habits. As revealed by the percentages of volumes in Table II, grasses, mainly *Panicum hians* Ell., made up the largest volume of the plant foods eaten, and algae of the genus *Oedogonium* made up the second highest plant food by volume, although more than twice as many individuals ate the latter. These algae were frequently dead when ingested, particularly in early summer. Grass was often in the same condition.

Sirens consumed a slightly higher volume of plants than of invertebrates and of the combined animal foods. The frequencies of occurrence, however, are exactly opposite.

The most important animal food was snails of the genus *Physa* with respect to volume, ostracod crustaceans with respect to number, and larval mayflies (*Ephemerella*) with respect to frequency of occurrence. The occurrence of *Physa*, ostracods and *Daphnia* in such measures is unexpected, since they were not observed to be especially numerous in the field or in bottom and seine samples. The occurrence of *Physa* as a food in such volume is particularly outstanding, because another snail, *Planorbis*, was about equally represented in bottom samples and was much more prevalent in seine samples. The morphology of *Planorbis* may account for its poorer representation as a food because it consists of a

flat coil. A moderate-sized snail would have a diameter too large for a siren to swallow. The decapod crustaceans, *Cambarus* and *Palaemonetes,* show a similar pattern to that of the snails, *Physa* and *Planorbis.* In this instance the very effective escape actions of *Palaemonetes* are possibly responsible for their poor representation in food samples.

Earthworms (*Lumbricus*) as well as pill "bugs" (*Armadillium,* Storer, 1943), crickets (*Gryllus*), true bugs (Hemiptera), leaf hoppers (Cicadellidae), ladybird beetles (Coccinellidae), spiders (Araneida), and millipeds (Diplopoda) represent terrestrial organisms made available to sirens by a rise in the water level following heavy rains. In fact, nearly all terrestrial organisms were found in the sirens taken on May 15, 1953, after previous heavy rains.

Certain insects, such as water scorpions (*Ranatra*), appeared to possess an immunity from depredations by sirens (as well as by fish in aquaria). This suggests a noxious secretion or some other protective device. Except for the larvae of the midges *Tendipes* and *Culicoides,* the several kinds of insects found in bottom samples were not present in the digestive tracts of sirens. This is possibly due to the protective devices of these animals.

By far the most important insect food was mayfly nymphs, *Ephemerella.* Although snails (*Physa*) constituted a larger volume, *Ephemerella* possibly constituted more actual food for sirens because they were completely digested, whereas snails (*Physa*) were only partially digested. Without exception, the shells of the latter were entire in the digestive tracts.

The category of mucus, which may have been partially solidified secretions caused by the alcohol-formalin killing solution, should correctly be included in the category of debris. Since the category of debris was reserved for that portion of the "foods" which either defied analysis or was accidentally ingested material that appeared in isolated cases, separate tabulation seemed justifiable.

Cardboard, included with the debris, appeared in thick pieces as if it had once been a pasteboard box. Several pieces had *Oscillatoria* attached to one surface. This suggested that sirens may have eaten the cardboard in order to obtain either the alga or invertebrates associated with it. Cigarette papers appeared in two individuals and cellophane in another.

The high percentage of debris may be ascribed to either fractions which have resisted digestion, such as the exoskeletons of insects and crustaceans, or acquisition of inorganic material taken with each mouthful of plant and/or animal food. Material which could easily have been silt, coagulated by digestive or preserving fluids, was present in the digestive tracts of some sirens. In five specimens there were grains of sand and larger quantities of "silt." Exposed sand was present in the pond only at the water line and the remainder of the substratum was covered by soft silt, so it does not appear unreasonable to assume that if five specimens contained sand then a much larger number should contain silt.

Weather Conditions. A negative correlation was found between the food habits of the sirens and all weather conditions except rainfall. When rainstorms and soil conditions permitted an amount of runoff

sufficient to raise the water level above the spillway, there were a large number of terrestrial organisms made accessible to sirens by their being carried into the pond by runoff water or by the water rising into the riparian zone.

DISCUSSIONS AND CONCLUSIONS

The proposition set forth by Dunn (1924) that sirens probably were herbivores had not actually been challenged until Davis and Knapp published the results of their study in 1953. However, Hurter's (1911) report that all sirens he had seen were caught on fish hooks baited with minnows and earthworms; Noble and Marshall's (1932) statement that exoskeletons, algae, and shells of bivalves were discharged by captive specimens; and Carr's (1940) record of plankton, crustaceans, insects, and annelids being eaten indicated clearly that sirens are not herbivorous animals.

The possibility that sirens might accidentally ingest invertebrates with plant food is not plausible when the local Negro fishermen know sirens only from ones which are caught on fish hooks baited with animal food, when more individuals contained invertebrates than plants, and when but a very small percentage contained nothing but plants. Why, then, were plants contained in greater volume than animal foods in sirens in this study? The answer is obviously that in all fresh water environments plants are usually of greater volume than the accompanying animals, and if the animals are mainly carnivorous and the plants of such nature that the capture of the animal prey could not avoid ingestion of plant food, then it seems likely that plants may be represented by a greater volume than animals. *Physa, Ephemerella,* and the entomostracod crustaceans are mainly vegetarians as established by my own observations and by references in Pennak (1953: pp. 352, 411, 514, and 671) and algae and grasses are difficult media from which to extricate such items.

The anatomy of the digestive tract of *Siren* belies the statement that it is herbivorous. It is a simple monogastric type, not possessing any grinding apparatus like that found in truly herbivorous nektors such as the gizzard shad (*Dorosoma cepdianum* Le Sueur) nor a special or enlarged intestine such as in rodents, lagomorphs, and ruminants. Indeed, the short digestive tract of *Siren* is indicative of carnivorous food habits.

Davis and Knapp (*op. cit.*) have stated that algae in the large intestine of sirens were frequently green. This may be interpreted that either the algae were poorly digested or that some algae were not digested at all. Samples of green algae from the lower intestine of sirens were cultured under similar conditions with control samples from the pond. None of the algae from the intestines made any growth, whereas the controls made a slight growth. Death was evident much sooner in the intestinal samples. Whether they were dead when taken from the intestines was not established.

The nature of the foods eaten by the sirens in this study was most similar to that reported by Davis and Knapp as might be expected. The Baetidae larvae, fragments of snail shell, and midge larvae that they report are very probably of the genera *Ephemerella, Physa,* and *Tendipes* (*Chironomus*), respectively. There is some disparity in these two studies,

as no caddis fly pupae were found in bottom samples in this study and *Myriophyllum* is not a plant of Country Club Lake.

Carr's study in Florida has more similarities with this study than does that of Noble and Marshall, in Arkansas. The presence of bivalves is rather surprising in the Arkansas specimens, because mussels (*Anodonta*) were plentiful in Country Club Lake but not one was found in our sirens. Although Hurter, in Missouri, and local Negro fishermen report that sirens take minnows used as fish bait, none was encountered as a food of the sirens in this study. Commercial shrimp used as bait was also taken by sirens.

Plankton (suspended microscopic organisms without powers of locomotion) were not found to be a food of sirens in this study.

Le Conte's study has been questioned, since he reported only "mud." Some of the specimens in this study contained inorganic debris, but never to the exclusion of other items.

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DEPARTMENT OF WILDLIFE MANAGEMENT, TEXAS A & M. COLLEGE, COLLEGE STATION, TEXAS

A MARYLAND HIBERNATION SITE FOR HERPTILES.—In the literature one finds but scant reference to the winter habits of Maryland amphibians and reptiles. The following note concerns an aggregation of *Chrysemys picta picta* (Schneider) and *Diemictylus viridescens viridescens* Rafinesque and a single *Rana pipiens* Schreber, found by Drs. R. S. Simmons and C. J. Stine, and the writer, at midnight, January 11, 1956, near Elkton, Cecil County. This area lies in Maryland's outer coastal plain, on the Del-Mar-Va peninsula.

The hibernating sites were two deep puddles, about twenty feet apart, which represented what remained of a moderate-sized fresh-water swamp following twenty-seven straight days without precipitation and one of the dryest winter periods here in many years. The first site was roughly rectangular, with dimensions approximately 30 x 36 inches horizontally, and 28 inches in depth, of which 14 inches was muddy water and 14 inches mud. Eight adult specimens of *Chrysemys*, 3 females and 5 males, were dredged from the mud of this puddle. They appeared in excellent condition, but were very torpid, capable of only feeble movements. After ten minutes they were capable of moving slowly about the ground. Most moved back to the puddle and plunged into the water. One specimen, a large male, wandered twenty feet afield.

From this same puddle were taken many specimens of *Diemictylus*, mostly females, all aquatic adults. None were observed swimming at the surface when the puddle was originally discovered. When dredged and seined out they were torpid. These newts were smaller and considerably more reddish in coloration than adult specimens from other regions in Maryland. It is very probable, in this writer's opinion, that the eft does not exist in the flat, low, Del-Mar-Va coastal plain.

A large female *Rana pipiens*, swollen with eggs, was dredged up from the mud of this first puddle. One specimen of the beetle *Cybister fimbriolatus* was found also.

The second puddle, approximately 36 x 48 inches and the same depth as the first, produced 12 *Chrysemys* (8 females and 4 males) and many *Diemictylus*. When the hole was first approached, half a dozen of the newts were actively swimming at the surface. Temperatures recorded when the pools were studied are as follows (in degrees Centigrade): at shoulder height, 4.3; 1 in. above ground 1 ft. from pool, 4.1; water in pool, 2.3; 4 in. below surface of mud under water, 3.0.

Since congregation here was not a strict matter of choice but a case of the puddles being the best sites available, the number of specimens of each species found should not be construed as a direct indication of population density of the swamp in spring and summer. It is likely that more than 20 *Chrysemys* inhabit this particular swamp, and a certainty that the lone *pipiens* taken was not all that existed there later in the year. The general area was muddy, and other newts, frogs, and turtles may have been hibernating elsewhere in less aquatic situations.—*John E. Cooper, Department of Herpetology, Natural History Society of Maryland, Baltimore.*

NESTING OF TEXAS HORNED LIZARDS. When we moved to our present home in south Fort Worth, Texas, several years ago we found a number of horned lizards, *Phrynosoma cornutum* Harlan, living in our back yard. We decided to play the part of observers only and to molest the lizards as little as possible. Each year newly hatched young appeared in our garden from about the middle of August until the middle of September, but only once were we able to have a nesting site for observation.

About ten o'clock on the morning of July 10, two small adult females were found digging in our tomato patch. At another place nearby, a hole had been started but abandoned. The two places where digging was in progress were about three feet apart, each being near the base of a tomato plant. The soil around each tomato plant was not the native limestone-derived soil, but a mixture of sand, peat moss, commercial fertilizer and native soil, being predominantly sand and peat moss. The entire garden was rather moist from a recent watering. It may be of some significance that the two lizards had chosen the artificially mixed soil in which to dig, for the abandoned hole was in native soil. Probably both lizards had been at work for an hour or more before they were discovered.

The lizards removed the earth by first scratching it to the rear with their front feet and then using the hind feet to push it farther back. The holes were dug on a slant of about 25 degrees and were of approximately the same size and shape as the respective lizards. Digging continued until both lizards were completely out of sight. No measurements were made, but the holes must have been at least 8 or 9 inches long and probably not much more than four inches in maximum depth. Between 1:00 and 2:00 p.m., the lizards remained out of sight in their holes except when I approached too closely, at which time they emerged but did not go very far from the entrances to their tunnels. It seems most likely that the eggs were laid during this period although the actual egg laying was not observed. Observations were interrupted at 2:00 o'clock, and were not resumed until 5:00 o'clock. By that time, the lizards had filled up their holes and built a small mound over the entrance to each tunnel. The mounds were oval, about 4 to 6 inches by about one half inch high at the center. Each lizard was resting on top of the mound she evidently had built. Scratch marks showed that each one had raked earth and debris from as far as three feet. Both deserted their mounds when I came too close, but returned when I went away. Neither was seen in the vicinity the next day. It was customary for us to give our tomato patch a rather thorough watering once every two weeks. This practice was continued. In addition, 3.42 inches of rain fell on the area between July 10 and September 13.

About 5:30 p.m., of September 13, my wife found a newly hatched *P. cornutum* at one of the nesting sites. There was a small hole in the ground and a second individual was in it. Careful excavation uncovered three more, at various depths up to three inches. The next morning a tiny hole was found in the ground at the second nesting site. Careful excavation here brought up twenty more hatchlings and a few empty egg cases from a depth up to about five inches. The hatchlings were measured and released in the tomato patch. Snout-vent lengths ranged from 20.6

to 23.8 mm., average 22.2. Total length ranged from 28.6 to 31.8 mm., average 31.1. It seems probable that most of the hatchlings from the first nest had already left the site, but I believe that all of the hatchlings from the second nest were recovered. The time of incubation, 65 to 66 days, appears to be somewhat longer than other observers have reported. It is possible that the periodic thorough watering of the garden may have retarded hatching somewhat. Newly hatched young, undoubtedly from other nests in the area, had been seen in the garden about three weeks before the present ones appeared.—*L. W. Ramsey, Box 441, T.C.U., Ft. Worth 9, Texas.*

FOOD HABITS AND TOXICITY OF THE VENOM OF THE NIGHT SNAKE.—A spotted night snake, *Hypsiglena torquata texana* Stejneger and a Texas earless lizard, *Holbrookia texana texana* (Troschel) were observed separately under a large limestone rock 24 miles west of Ozona, Crockett County, Texas, on August 8, 1950, at 1:30 p.m. The writers, working together in order to capture both specimens, carefully lifted the rock and found the snake had grasped the lizard in the right axillary region. The snake, when captured, released its hold on the lizard. The lizard was apparently unharmed. The two individuals were placed in a container where the snake immediately resumed its attack and again grasped the lizard in the right axillary region. Within three minutes the *Holbrookia* was dead. The snake then attempted to swallow the lizard. Several times the *Hypsiglena* succeeded in swallowing the head and neck of the lizard but apparently it could not engulf the forelegs. About one hour after the death of the lizard the snake ceased its attempts to feed and thereafter ignored the dead lizard.

The *Hypsiglema,* Texas Nat. Hist. Coll. 11609, is 44.9 cm. in total length, 38.2 cm. snout-vent, 6.7 cm. tail length, 10.5 mm. head width. The *Holbrookia,* Texas Nat. Hist. Coll. 11646, is 69.5 mm. snout-vent, 13.5 mm. head width; the broken tail is 38.5 mm. in length.

The earless lizard succumbed to the toxicity of the night snake much more rapidly than reported in *Xantusia, Coleonyx* and *Cnemidophorus* (Cowles, 1941, Copeia, (1):2-4). This is perhaps due to the large size of the snake. It is possible that the snake had attacked the lizard previous to our first observation. However, the activity of the lizard when captured was apparently quite normal and none of the symptoms of toxemia described by Cowles in *Xantusia* was noted.—*David L. Jameson and Aubrey M. Jameson, Jr., Department of Biology, University of Oregon, Eugene, Oregon.*

Early Life History of Two Philippine Frogs with Notes on Deposition of Eggs

By ANGEL C. ALCALA and WALTER C. BROWN

The almost complete lack of information on the breeding habits and early stages in the life histories of native Philippine amphibians may be noted by reference to Taylor (1921) and Inger (1954). Our knowledge has been largely limited to two brief reports, Villadolid and Rosario (1930) and Cendaña and Fermin (1940). The earlier paper dealt with limited observations on *Rhacophorus leucomystax quadrilineatus* (Boie) and the later one with breeding habits and eggs of *Kaloula picta* (Duméril and Bibron).

The authors while conducting field work on Negros Island were fortunately able to obtain eggs or early embryonic stages of several species. These were transferred to the Biological Laboratories at Silliman University where they were placed in glass aquaria of 5 to 10 gallon capacity and observed throughout the period of embryonic and larval development.

Water in the tanks was freshened every 3 or 4 days. A mixture of blue-green and green algae, placed in the aquaria, served as food for the larvae, and aquatic plants (*Hydrilla* sp.) were used in the beginning to help maintain an adequate oxygen supply. Later an electrically operated aerator was used. Water lettuce (*Pistia statiotes* Linn.) or thin corks served as floats for transforming individuals. The temperature of the water in the aquaria remained relatively uniform, varying only from day to night or with atmospheric conditions. Between November 14 and December 12, 1954, it was noted at various times between the hours of 6:00 a.m. and 10:00 p.m. daily. The range was from 25.5 to 28.5 degrees centigrade.

Specimens were removed from the aquaria and preserved at frequent intervals throughout the developmental period; the number, in most instances, was dependent upon the stock available for each species. Measurements are based upon freshly preserved materials.

The present paper is concerned with two species, *Rana microdisca leytensis* Boettger and *Rhacophorus leucomystax quadrilineatus*. The series of specimens used in this study is deposited at the Natural History Museum, Stanford University, California, and the Biological Laboratories, Silliman University, Negros Oriental, Philippines.

Rana microdisca leytensis Boettger

Breeding habits. The senior author observed a pair in amplexus on the upper surface of a leaf of a badyang plant, *Alocasia macrorrhiza* (Linn.), about 3 feet above the surface of a small, slow-moving stream in Sitio Batakon, Cauayan, Negros Occidental, on December 29, 1954. This plant is a member of the shrub stratum of the forest overshadowing the streams in this locality. The immediate association was a swampy patch of forest at an altitude of about 500 feet. After the pair was collected a few eggs were observed attached to the anal region of the female and eggs were found on the leaves.

Embryos in late stages of development, prior to escape from the egg capsules, were collected by the authors along a small stream in the Ocoy River valley about 14 kilometers west of Dumaguete City, Negros

Oriental, on August 17 and 19, 1954. This stream is also slow-moving at this point and well shaded. The altitude of the collecting site was between 500 and 600 feet. The first collection of about 30 embryos was found on the surface of a dead leaf lying on the sandy bank several inches from the edge of the water. The egg capsules adhered to each other and formed a twice-coiled string. The second collection of about 60 eggs was made 2 days later at the same general site. These were on the moss-covered surface of the exposed root of a sago palm several inches above the surface of the water. There was no evidence of stream recession at this time. Further field observations are necessary to determine whether or not eggs of this and other subspecies are generally or always deposited in such situations and to establish the method by which the hatchlings reach the water where the larvae are found. These three observations strongly suggest that at least this subspecies of *Rana microdisc*a probably does not deposit eggs in the water.

Similar rhacophorid-like habits in the deposition of eggs are also known for a few other species of the genus *Rana*. Observations by the authors (Brown and Alcala, 1955: 97) indicate that *Rana macrodon acanthi* Taylor also deposits in situations other than water. Rose (1950: 36-39) notes that *Rana grayi* Smith, which occurs in South Africa, also lays its eggs out of water; and Liu (1950, pp. 252-259) makes the same observation concerning *Rana adenopleura* Boulenger which occurs in Formosa and China.

Eggs. In the instances of the collections in both the Ocoy River valley and Sitio Batakon, hatching began within a matter of hours after the collection was made. Examination of eggs preserved at the time of collecting reveals that those of August 17 were in the external gill stage and probably about ready to hatch; those of August 19 were in part at about this same stage of development and in part in an early elongation stage following the formation of the neural tube.

Larvae. Larvae at the time of hatching have well developed external gills and a prominent opercular fold. There is no evidence of oral suckers. The mouth is open but larval teeth and beak are not evident. This would most closely approximate stage 23 of *Rana pipiens* (Shumway, 1940: 147) in the above mentioned features. However, the egg masses were subjected to considerable jostling during transport to the laboratory and this disturbance might presumably have caused hatching at a somewhat earlier stage than normal. Further observations on hatching of undisturbed egg masses in the normal habitat are necessary to determine this. Nine specimens measured from 8 to 9 mm. total length. Growth and change in form during the larval period are summarized in Table 1. The duration of the larval stage of specimens from the Ocoy River (collected in August) ranged from 90 to 109 days; from the Batakon area (collected in December) from 82 to 120 plus days.

No specimen measured prior to the formation of hind limbs attained a total length of more than 41 mm. The body is depressed. The eyes dorsolateral in position. The nostril is a little closer to the eye than to the tip of the snout. The spiracle is tubelike (about 1 mm. in length) on the left ventrolateral surface, directed backward and upward and a little closer to the eye than to the vent. The anus forms a short tube opening to the right of the ventral fin. The tail is about one and two thirds times the

length of the body and sharply pointed posteriorly. The muscular portion is well developed. The dorsal fin originates near the base of the tail or occasionally slightly posterior in some individuals from Batakon. The tail is moderately high, the dorsal fin somewhat wider than the ventral at its widest point. The mouth is antero-ventral. It is bordered by a marginal row of papillae laterally and ventrally except for a narrow, median ventral gap. At the time of maximal development of the horny teeth, the upper lip bears a single long row. There are three on the lower lip of which the uppermost has a moderately long gap in the middle while the other two are unbroken. The lower row is about half or slightly more than half the length of the middle row. Thus the dental formula is I/II:1-1 (Fig. 1). Older larvae exhibit variation especially of the lower rows in the form of asymmetrical breaks or, at times, reduction to two rows. Very young larvae also exhibit fewer rows of teeth or incompletely developed rows. Sufficient material is not available at this time to measure the variability at any selected stage of development or to estimate what per cent, if any, fail to attain maximal development of larval teeth. The beaks of the jaws are blackish with serrated edges.

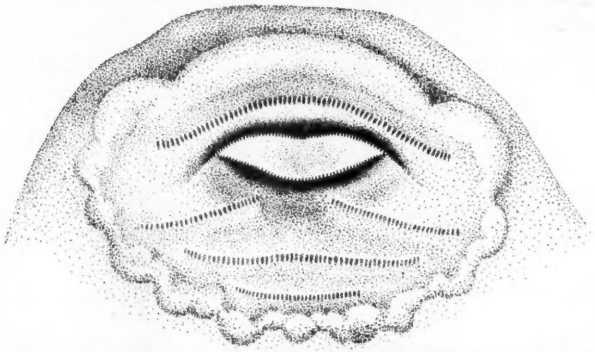

Fig. 1. Larval mouthparts of *Rana microdisca leytensis* Boettger.

Larvae with well-developed hind limbs have the toes webbed nearly to the disk except for the fourth.

Color (in preservative). At the time the hindlimb buds begin to appear the dorsum and lateral surfaces are mottled brownish. A narrow, darker line on either side of the head extends from near the tip of the snout to, or nearly to, the anterior corner of the eye. The muscular portion of the tail and the dorsal fin are pigmented much as the body. The ventral fin is somewhat lighter. Pigmentation of the fins appears to develop gradually up to about this stage. The venter is much lighter, marked with brownish flecks anteriorly, non-pigmented posteriorly.

Habits. Tadpoles were generally observed to be motionless on the bottom of the tank or among the submerged plants. They tended to move about only when feeding or disturbed.

Fourteen completely transformed young range from 11 to 13 mm. snout to vent length.

Rhacophorus leucomystax quadrilineatus (Boie)

Breeding habits. Embryos were collected in a whitish, foamy egg mass which was attached to a mat of grass only a few inches high and about one foot from the edge of a shallow pond on December 30, 1954. The pond, a temporary carabao wallow, was situated in a small meadow-like clearing and was both fed and drained by a small sluggish stream. The site of the pond was on the north slope of the ridge just south of Mayaposi Spring, Negros Oriental, at an altitude of about 2000 feet. A portion of the egg mass was preserved in the field, and the balance was transferred to the Biological Laboratories at Silliman University on December 31.

TABLE 1.

Age and Size (under laboratory conditions) of Selected Developmental Stages

Species	Stage	Age after hatching in days	Total length in mm.	No. of specimens
Rana microdisca leytensis	External gill	-0-	8.0-9.0	9
	Hind limbs short	68-87	36.5-40.5	3
	Hind limbs well developed	80-114	34.5-41.0	5
	Both limbs well developed	85-114	30.5-37.6	5
	Completely transformed	90-109	11.0-13.0	14
Rhacophorus leucomystax quadrilineatus	External gill	-0-	4.5-5.5	10
	Hind limb buds	41-55	24.0-30.0	3
	Hind limbs well developed	63-83	38.0-44.0	2
	Both limbs well developed	83	32.5	1
	Completely transformed	70-110	14.0-17.5	6

Eggs. Although no unsegmented eggs or early cleavage stages of this species were obtained, the very large yolk mass of the early embryonic stages measured approximately 2 mm. in diameter, which is probably very near to the diameter of the egg. The eggs are unpigmented.

Embryos. The embryos, at the time they were collected, exhibit an elongate tail bud and ten or eleven somites can be counted. The head region is enlarged. Development from this stage was sufficiently rapid, however, that many were hatched by the time the egg mass reached the laboratory, about 30 hours later, December 31. As in the instance of *Rana microdisca leytensis* the effect on time of hatching caused by disturbing and transporting the egg masses is unknown.

Larvae. Larvae at hatching have well-developed external gills and a deep stomodeal pit, but the mouth is not open. A rounded protrusion (probably adhesive organ) is evident on either side behind the pit and generally a well-differentiated, non-pigmented eye is present. Whether the larvae are, under natural field conditions, free-living in open water

at this stage or retained in a liquified central portion of the foam-mass is unknown at this time.

Larvae at hatching in the laboratory were ivory white, apparently without pigment or nearly so. Microscopic examination following preservation of the larvae at this stage reveals a few melanophores on the dorsal and lateral surfaces of the body and the upper margin of the covering of the relatively large yolk mass, but they are absent on the tail. By the end of the first day the animals were rather darkly pigmented except for the tail fins. Data on the release mechanism as well as details of the pattern and rate of development of the pigment are unknown.

Ten specimens, preserved at hatching, measured 4.5 to 5.5 mm. total length. The duration of the larval stage ranged from 70 to 119 plus days. The limited information available to us on growth is summarized in Table 1.

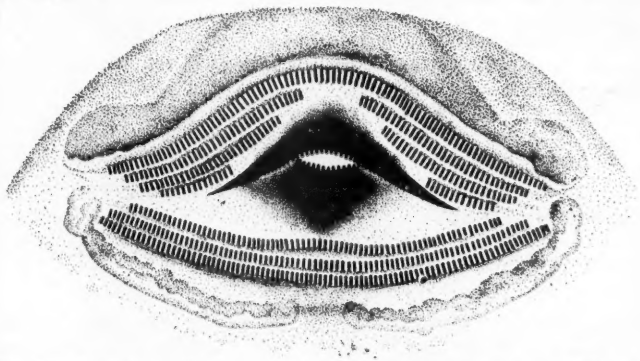

Fig. 2. Larval mouthparts of *Rhacophorus leucomystax quadrilineatus* (Boie).

Hind limb buds were evident by the time a total length of 24 to 30 mm. had been attained. The body is almost cylindrical. The eyes are more lateral than dorsal but visible dorsally. The nostril is a little closer to the tip of the snout than the eye. A light line, faint and narrow anteriorly, is present between the nostril and the anterior corner of the eye. The spiracle is slitlike, ventrolateral in position, its opening pointing backward and upward, a little closer to the eye than the vent. The anus forms a short tube opening to the right of the ventral fin. The tail is about one and one-third times the length of the body and is pointed posteriorly. It is rather high, the dorsal and ventral fin of nearly equal breadth. The dorsal fin originates at the base of the tail The mouth is anteroventral with a marginal row of papillae laterally and ventrally except for a narrow, median gap in the latter. There are four rows of teeth on the upper lip at maximal development, only the outermost of which is undivided; the others exhibit moderate to large median gaps. There are three rows on the lower jaw which are continuous, except for the inner one on several very young larvae (Fig. 2). The dental formula at maximal development is I:3-3/III. Younger

larvae exhibit fewer rows of teeth, but sufficient material is not available at the present to state with any degree of certainty the rate of development or the amount of variation at any given age.

Larvae with well-developed hind limbs have the toes webbed as in adults.

Color (in preservative). At the time the hind limb buds are formed both dorsal and ventral surfaces of the body are rather darkly mottled (blackish or blackish brown). The muscular part of the tail and the proximal portion of the dorsal fin are heavily mottled. The rest of the fin area exhibits more scattered pigmentation. By the time the hind limbs are well developed the fins are, in general, heavily pigmented except near the tip.

Habits. In the aquaria the larvae were generally observed to be actively swimming and feeding on the algae adhering to the partly submerged plants during the day or when the laboratory was artificially lighted. Larvae were also observed to feed on soft parts of two, dead, metamorphosing young.

Six completely transformed young range from 14 to 17.5 mm. snout-vent length.

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The Status of *Sphaerodactylus gibbus*

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Sphaerodactylus torrei Barbour (1914, Mem. Mus. Comp. Zool., 00:260) was briefly described as follows: "*Type*:—No. 6916, M.C.Z. An adult, Santiago de Cuba, . . . Dirty brown or whitish, upper surfaces with five dark brown bands between the end of the snout and sacrum, three anteriors often extending almost or quite across neck and chest. A varying number of complete bars on tail. Two longitudinal whitish stripes on the snout." Three specimens other than the type were mentioned.

In his monograph on *Sphaerodactylus* (1921, Mem. Mus. Comp. Zool.,

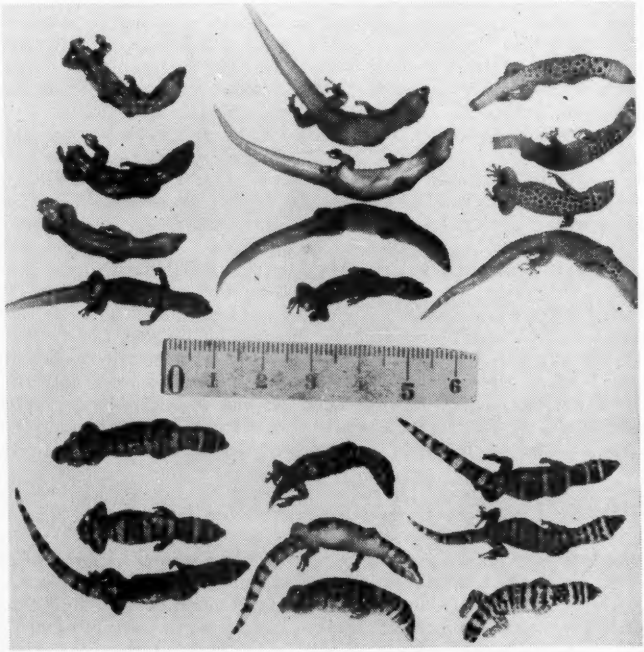

Fig .1. Figures below the mm rule are all females. Note the variation in pattern. The three specimens at right faintly show the typical female white lines from between eyes to snout and the pairs of white dots in the interspaces. The background color is usually gray, but occasionally mahogany brown. Figures above the mm rule are all males. Note lower left shows female pattern breaking up. Next specimen to the right and next lowest on right show maximum spotted phase. Bottom and top figures on right show spots disappearing to form adult male color pattern as shown by three upper center figures.

00:230) the coloration of *S. torrei* was redescribed as follows: *"Colour*: —Females are grayish or light brown with varying cross-bands. These may be clearly defined with dark edges and pairs of white spots or they may appear simply as darker rather ill-defined, dusky transverse zones. Male specimens are uniform gray-brown or very faintly barred."

In the same monograph (*op. cit.:* 228) *S. gibbus* was described as a new species from Stocky Island, Exuma Cays, Bahama Islands, from the type (MCZ 13436) and two paratypes (MCZ 13435, 13437). The coloration was described as follows: *"Colour:*—Light reddish brown with large coarse dots of darker brown. Belly pale ashy gray. In some cases the spots are wholly wanting . . . Since writing the above Mr. C. T. Ramsden has shown me two spotted sphaerodactyls from Cuba (1 from Santiago, the other from Guantanamo) which in habit and squamation decidedly recall *torrei.* They differ, however, so widely in colouration that I have decided to let *gibbus* stand as a full species until *torrei* is shown to vary sufficiently to include it." The specimen from Guantanamo was listed (*op. cit.:* 275) as MCZ 14665, but the one from Santiago is not listed.

In 1930, however, Barbour regarded *S. gibbus* as "known only from the Exuma Cays "(Zoologica, 9: 83). Three years later he again added *S. Gibbus* to the Cuban fauna (Copeia, 1933: 275), apparently having overlooked the reference to Cuba in the original description: "Dr. Carlos G. Aguayo . . . sent me a specimen of *Sphaerodactylus* . . . I surmised that it was *S. gibbus,* a species which I described from the Exuma Cays in the Bahamas some years ago. My colleague, Arthur Loveridge, made a careful comparison with the material and confirms my identification, thus adding another new species to the fauna of Cuba . . . He (Dr. Aguayo) found it at Calabazas, near Holguin, Province of Oriente, Cuba."

Yet in 1935 (Zoologica, 19: 101) Barbour again overlooked the records of *S. gibbus* for Cuba, stating its range as "known only from the Exuma Cays." Not until the third checklist of Antillean amphibians and reptiles appeared (1937, Bull. Mus. Comp. Zool., 82: 111) was Cuba admitted to the range of *S. gibbus:* "Bahama Islands and eastern Cuba."

Barbour and others have collected or seen banded female *torrei* and monochrome male *torrei,* but apparently no one has suspected that the male hatches with markings similar to the female, and that in its ontogeny the bands in males change to spots and finally disappear. I know of no other case in which there is such a marked double change in color pattern.

Our series of 82 adults taken at Banes, Oriente, Cuba, April 5-16, 1956, proves that the Cuban *"gibbus"* is a transitional color phase of the male *S. torrei* (see Pl. 1). If, as Mr. Loveridge states, the Cuban *"gibbus"* is identical to *S. gibbus* of the Exuma Cays, it follows that *S. gibbus* is a synoym of *S. torrei* and that the distribution of *S. torrei* should include the Exuma Cays.

The color of a hatchling was black with light, almost white, bands. The first band just behind eyes; another high on the neck passing all the way around; next at shoulders; two across body; one at sacrum and 5 around tail. Between the body stripes were pairs of minute white dots and from between eyes to snout two white lines, the pattern typical of

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